LAND/WILDLIFE INTEGRATION NO. 3

Proceedings of a technical workshop to discuss the incorporation of wildlife information into ecological land surveys

16-19 September 1985
Mont Ste-Marie, Quebec

Compiled by
H.A. Stelfox and G.R. Ironside

Ecological Land Classification Series, No. 22

Land Conservation Branch
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INTÉGRATION TERRE/ FAUNE Nº 3

Compte rendu d'un atelier technique sur l'introduction de l'information sur la faune dans les relevés écologiques du territoire

16-19 septembre 1985
Mont Ste-Marie, Québec

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Série de la classification écologique du territoire, no. 22

Direction de la conservation des terres
Service canadien de la faune
Environnement Canada

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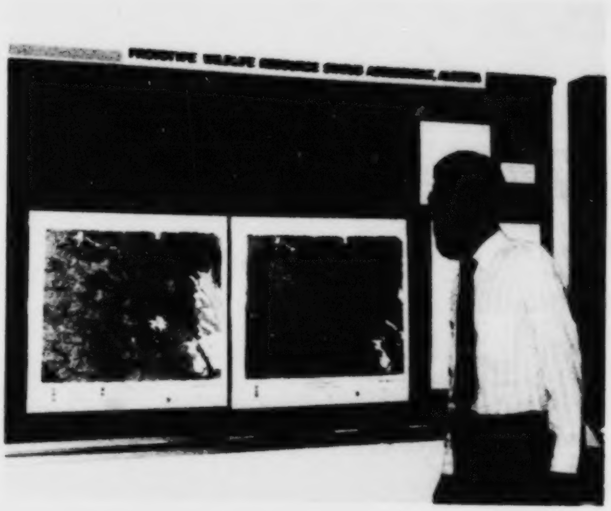

OPENING REMARKS

H.A. Stelfox
Fish and Wildlife Division
Alberta Department of Forestry, Lands and Wildlife
Edmonton
Alberta

It was a pleasure to welcome friends and colleagues from across Canada and the United States to the Wildlife Working Group meeting at Mont Ste-Marie, Québec. It was gratifying to see the continued interest and support for the Group's activities, both as indicated by their presence and also as expressed by several individuals who wished to attend, but could not due to work schedules or travel logistic problems. I particularly enjoyed greeting several colleagues from Quebec who were able to host such a beautiful setting for the workshop. Their presence was appreciated, as it helped us to make it a truly national workshop. Unfortunately, it was not practical for us to make the workshop fully bilingual by way of providing formal translation services from English to French and vice-versa. However, we did have both French language and English language contributions at the workshop, as we also had at the workshop at Banff in March, 1982.

The Wildlife Working Group (WWG) was formed officially in October of 1980 as an addition to the working groups already formed under the umbrella of the Canada Committee on Ecological Land Classification (CCELC). The CCELC is primarily concerned with the development and application of integrated ecological land surveys (ELS). Emphasis on ELS methods during the mid- to late 1960's and throughout the 1970's was focussed on integrating vegetation, landforms and soils, as well as water and wetland classification regimes and mapping presentations. With the formation of the WWG in 1980, it was intended that the ELS process be further developed to address and integrate faunal considerations so as to further strengthen the ecological approach to landscape classification and evaluation.

The purpose of the WWG was further expanded during the early stages of its formation to give us a goal statement that now reads: "To encourage and facilitate the development of effective and standardized methodologies for wildlife habitat classification and evaluation, as well as to further the integration of wildlife values within an ecological land survey framework". The term "wildlife" is used in its broadest sense to include all non-domesticated animal life. This goal statement recognizes two perspectives within the WWG — that of the wildlife resource manager who needs primarily wildlife inventory and evaluation data, and that of the land use planner and manager who needs resource data on several different land use considerations, wildlife being just one.

To meet this goal, a primary function of the WWG has been to facilitate an exchange of ideas and foster discussions between individuals across Canada, who have a common interest in this subject matter. To this end, periodic workshops are held and newsletters are distributed. An additional vehicle designed to further the objectives of the Working Group is the current development of a guidelines manual for the integration of wildlife resource assessment techniques with ecological land survey methods. This was a very important topic of discussion for the workshop, along with the verbal and poster presentations.

Before turning the meeting over to the first session chairperson, I took the opportunity to particularly thank two individuals who were instrumental in assisting with preparations for the workshop. Gary Ironside of the Lands Directorate in Hull provided most of the logistical support, including arrangements for the facilities, distribution of agenda and travel information and much more. John Kansas, a consultant based out of Calgary, was instrumental in converting a detailed outline and preliminary content for the guidelines manual into a substantive draft document suitable for review and discussion at the workshop. I also took the opportunity to formally announce the transfer of chairmanship responsibility for the WWG over to new co-chairpersons — Paul Gray from the N.W.T. Wildlife Service in Yellowknife and Gaétan Guertin of the Environment Division of Hydro-Quebec in Montreal. Paul and Gaétan will bring new energies and initiatives to this responsibility.

INTRODUCTION

H.A. Stelfox
Division des ressources fauniques
Ministère des forêts, des terres et de la faune
Edmonton
Alberta

C'était un plaisir de souhaiter la bienvenue à mes amis et collègues canadiens et à nos deux collègues américains. Il était agréable de constater l'intérêt et le soutien qu'ils ont apportés aux activités du Groupe de travail sur la faune, comme en a témoigné la forte présence à l'atelier et le nombre de personnes qui auraient bien voulu participer mais qui en ont été empêchées par des problèmes d'horaire de travail et de transport.

Je tenais à remercier tout spécialement nos collègues du Québec qui nous ont accueillis dans un cadre aussi agréable. Leur présence a été particulièrement appréciée, car elle a contribué à faire de cet atelier une réunion véritablement nationale; de plus, leur expérience précieuse et leurs connaissances ont apporté beaucoup aux délibérations. Malheureusement, pour des raisons d'ordre pratique, l'atelier n'était pas entièrement bilingue, car aucun service de traduction de l'anglais vers le français et du français vers l'anglais n'avait été prévu. Cependant, les communications étaient présentées tant en anglais qu'en français, comme c'était le cas lors de l'atelier qui s'est tenu à Banff en mars 82.

Le Groupe de travail sur la faune, officiellement constitué en octobre 1980, est venu s'ajouter aux autres groupes de travail formés sous l'égide du Comité canadien de la classification écologique du territoire (CCCET). Le CCCET s'intéresse principalement à la mise au point et à l'application de relevés écologiques intégrés du territoire (RET). Du milieu à la fin des années 60 et durant les années 70, les méthodes de RET étaient principalement orientées sur l'intégration des systèmes de classification et de présentation cartographique de la végétation, des paysages et des sols, ainsi que des eaux et des terres humides. Avec la formation du Groupe de travail sur la faune en 1980, on se proposait d'améliorer le procédé RET pour tenir compte et intégrer les aspects relatifs à la faune, en vue de renforcer l'approche écologique de la classification et de l'évaluation des paysages.

L'objectif du Groupe de travail sur la faune a encore été élargi peu de temps après la création du groupe, et maintenant il se définit comme suit : "encourager et faciliter la mise au point de méthodes uniformisées et efficaces de classification et d'évaluation des habitats fauniques, et poursuivre l'intégration des paramètres fauniques dans le cadre d'un programme de relevé écologique du territoire". Les termes "faune" et "faunique" sont employés dans leur sens le plus large : le premier désigne tout animal non domestique et l'autre qualifie tout ce qui s'y rapporte. Cet objectif tient compte de deux perspectives au sein du Groupe de travail sur la faune : celle du gestionnaire des ressources fauniques, qui a surtout besoin de données sur l'inventaire et sur l'évaluation des paramètres fauniques, et celle de la personne chargée de la planification et de la gestion de l'utilisation de terres qui a besoin de données sur plusieurs aspects de l'utilisation des terres, la faune ne représentant qu'un seul de ces aspects.

Pour atteindre cet objectif, le Groupe de travail sur la faune s'est principalement efforcé de faciliter l'échange d'idées et de favoriser la discussion entre des personnes à travers le Canada et, à un moindre degré, à l'étranger qui s'intéressent à ce sujet. A cette fin, des ateliers sont organisés périodiquement et des bulletins d'information sont distribués. On prépare actuellement un manuel sur les lignes directrices à suivre pour intégrer les techniques d'évaluation des ressources fauniques dans les méthodes de relevés écologiques du territoire. Ce manuel constitue un autre moyen de réaliser les objectifs du Groupe de travail. Il s'agissait là d'un élément très important de l'atelier, au même titre que les communications orales et les séances d'affiches présentées.

Avant de céder la place au président de la première séance, j'ai profité de l'occasion pour remercier tout particulièrement deux personnes qui ont beaucoup collaboré à la préparation de cet atelier. M. Gary Ironside, de la Direction générale des terres (Hull), s'est occupé de la plupart des aspects techniques; il s'est chargé de trouver les locaux que nous avons occupés, de distribuer l'ordre du jour et des renseignements concernant les transports, et de bien d'autres choses encore. M. John Kansas, un consultant dont le bureau se trouve à Calgary, nous a aidé à rédiger, à partir d'un aperçu détaillé et d'un texte préliminaire pour le manuel de lignes directrices, un document provisoire substantiel se prêtant bien à l'examen par les participants à l'atelier.

Enfin j'ai profité de l'occasion pour annoncer officiellement la nomination de nos nouveaux co-présidents du Groupe de travail sur la faune; il s'agit de M. Paul Gray du Service de la faune des Territoires du Nord-Ouest, à Yellowknife, et M. Gaétan Guertin de la Division de l'environnement de l'Hydro-Québec, à Montréal. Je suis sûr qu'ils consacreront toutes leurs énergies et leur esprit d'initiative à s'acquitter de leurs fonctions et qu'ils pourront toujours compter sur votre aide au cours des différentes activités du Groupe de travail sur la faune.

BACKGROUND PAPERS/ÉTUDES DE FOND

"WILL YOUR CLASSIFICATION HELP SUPPORT MORE WILDLIFE?"

D.J. Neave
Executive Director
Wildlife Habitat Canada
Ottawa
Ontario

In preparing this paper, I welcomed the challenge to find a stimulating topic — one that is thought provoking, novel, and reflects my own optimistic view-point regarding the future of wildlife conservation.

The subject of this paper is stools -- three-legged stools. I hope that I am first to discuss this subject, as stools are fascinating and, as with many wildlife habitats, are also in danger of disappearing. The three-legged stool is an excellent analogy for wildlife habitat as the three legs represent the three components of habitat: food, cover, and space. The seat represents the carrying capacity -- **the amount of wildlife that the habitat can support,** and hence the title of this paper.

The stool analogy can easily be related to habitat in Canada. If one leg is weak or shorter than the others, the stool will tip or collapse and support less or no wildlife. Many habitats are tipping and some are going over. However, my point is not about the status of habitats, but the reason why habitats (stools) are in low demand in the market place. I am going to extend the analogy by discussing Bernie, for the businessman's viewpoint on stool production and marketing, and Willie, for the wildlifer's viewpoint on habitat maintenance and development.

Bernie's company produces three-legged stools by:

1. making a commitment to manufacture and sell stools to make a profit. This statement of purpose and intent is backed with appropriate fiscal resources.
2. developing a long-term strategy or comprehensive plan for producing the various components, assembling and marketing stools (after examining the competition), inventorying resources, and analyzing the demand and costs.
3. proceeding with actual production and marketing.

Willie's efforts unfortunately miss some steps that should be included in habitat production:

1. A clear statement of intent to ensure that there is sufficient habitat to meet the various species goals based on user demands. This commitment should be reflected in legislation, manpower, and resources.
2. A comprehensive plan, addressing what habitats are required, where, and the minimum quality and quantity. This should address current and future problems, being competitive, complementary to other resource producers, and cost effective.
3. A spectrum of balanced activities, from inventory through to protection and development to monitoring and extension.

As one of the Willies, involved in the past with government and now in the private sector, I have to be critical of existing habitat programs in Canada as:

1. There is virtually no habitat policy in Canada, at the federal or provincial level, reflected in legislation.
2. There are very limited manpower and resources for habitat management that often have been stolen from other parts of small wildlife agencies programs.
3. There are no comprehensive strategies in habitat programs.

Returning to the analogy, there is much production of legs and support struts, of different sizes, colours, and shapes. However, insufficient planning results in a tipsy stool with a progressively smaller seat supporting less wildlife. Little thought is given to marketing these products which are often perceived as weird looking and as having limited value. My reason for using this analogy is that it emphasizes the need for habitat managers to become businesslike and to take advantage of the emerging opportunities relative to our needs.

We need bold plans, clear goals, and commitments. The North American Waterfowl Management Plan, for example, will provide us with a policy and a government commitment with extra needed resources.

Secondly, we must have a clear, well-accepted and well-adopted plan of action. We must quickly and aggressively develop comprehensive habitat strategies and develop new tools in habitat production and marketing. Habitat managers must not only have new management techniques, but also feel confident of what they have to manage.

Thirdly, we must use the same factors as other people in the market place. There is growing evidence of the importance of wildlife to the Canadian economy. Statistics Canada has further reviewed Canadian Wildlife Service data and indicates that "the 4.2 billion dollar expenditure resulted in the creation of 185 000 jobs with resulting personal income of 3 billion dollars in 1981. This also represents a capitalized value of over 17 billion dollars".

Lastly, we need additional help, new ideas, and functioning programs.

These points represent the challenge for the Wildlife Working Group of the Canada Committee on Ecological Land Classification. They are also the "raison d'être" of Wildlife Habitat Canada. We introduced our foundation with the catchy phrase "Canada's wildlife habitats are the envy of the world". This statement is difficult to prove when we have such limited knowledge of the abundance and distribution of the spectrum of wildlife resources in Canada. Willie's inability to determine the loss of habitats and to determine goals is well known. Trying to adopt marketing approaches, trying to develop a system that allows for the dynamics of changing landscapes, and trying to retain future options may be a dream, but it is possible.

Wildlife Habitat Canada is a relative fledging foundation created to help restore and retain the great diversity of habitats in Canada.

In the support function, Wildlife Habitat Canada in its first year of operation provided financial support for 24 cooperative projects to a total of $ 1 277 500 to aid 31 non-government agencies and various government departments. These projects have emphasized wetlands, such as Horseshoe Lakes in Saskatchewan or Big Hay Lake in Alberta. They have also included the acquisition of an island in an estuary important for whales and seabirds, a floodplain harbouring an endangered plant, and a critical winter range for bighorn sheep.

It is catalyst function, we are: stimulating new habitat initiatives through examining tax legislation and financial incentives; challenging economists on the socio-economic value of wetlands; and encouraging property tax relief and municipal involvement in Minnedosa, Manitoba and Redvers, Saskatchewan. We have funded the development of an exciting new concept, mortgage relief, where conservationists can acquire land with an interest-free loan or at a reduced rate of interest. One of our most exciting current activities has been helping incorporate agricultural soil and water initiatives as a component of the North American Waterfowl Management Plan. We have had some success and have started a similar approach in forestry to incorporate silvicultural financial incentives to habitat production.

In the watchdog or assessment function, we are providing a report on the status of wildlife habitats, programs, and opportunities in Canada. It should not only provide the foundation with a long-range goal, but hopefully provide a much needed benchmark in Canada. We are also appearing to have some success in influencing changes to the grain quota system's impact on habitat.

Funding is obviously critical. The federal government provided $3 000 000 in administrative start-up funds with initial subsequent funding being generated by the sale of a $4.00 wildlife habitat conservation stamp this fall. Bob Bateman painted the scene for the first stamp. Besides the mandatory acquisition of the stamp by 400 000 migratory bird hunters, we are optimistic about selling 1 200 000 stamps in total and over 50 000 prints. We are also considering other opportunities, including a conservation share approach.

Wildlife Habitat Canada will not have the highly visible field force and be an active developer of habitat. Perhaps we can best be perceived as the glue, a member of the design team, and a member of the company's auditors -- some of wildlife's missing components in our stool analogy.

In conclusion, my response to the question in the paper title is: yes, your classification will help support more wildlife. The incorporation of your comprehensive approach will be like adding the necessary support strut to the legs of a weak stool. You have the interest and apparent financial support of Canadians, great opportunities, and a new national foundation to encourage fresh ideas.

A REGIONAL WILDLIFE ECOSYSTEM CLASSIFICATION FOR BRITISH COLUMBIA

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Ministry of Environment
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ABSTRACT

The accompanying report describes a classification intended to clarify and to categorize the complex ecosystems that exist in the Province of British Columbia as a basis to describe the ecological requirements of terrestrial vertebrates. This classification of wildlife ecosystems into a regional hierarchy defines, for wildlife managers and planners, areas of similar biological potential. It forms the upper levels for the B.C. Ministry of Environment's Biophysical Habitat Classification. The identification of each wildlife ecosystem is based on characteristic climatic processes, landforms, and animal distributions. Thus, each unit portrays an area with similar management potential. One map is also provided.

This classification of regional-scale wildlife ecosystems has evolved through much discussion with wildlife managers, planners, and foresters. This report has been completed through the efforts and encouragement of three people: Bruce Pendergast, Norm Sprout, and Bob Marsh.

RÉSUMÉ

Le rapport ci-joint présente une classification qui a pour but de préciser et de catégoriser les écosystèmes complexes en Colombie-Britannique et sur laquelle on pourrait s'appuyer pour décrire les exigences écologiques des vertébrés terrestres. Cette classification des écosystèmes fauniques au sein d'une hiérarchie régionale définit, à l'intention des gestionnaires et des planificateurs de la faune, les régions possédant un potentiel biologique semblable. Elle constitue les échelons supérieurs de la classification biophysique (écologique) des habitats élaborée par le ministère de l'Environnement de la Colombie-Britannique. L'identification de chaque écosystème faunique est basée sur les processus climatiques, les paysages et les distributions de la faune caractéristique, et chaque unité dépeint ainsi une région présentant le même potentiel de gestion. Le rapport est aussi accompagné d'une carte.

Cette classification des écosystèmes fauniques à l'échelle régionale s'est développée grâce à de nombreuses discussions avec des personnes spécialisées dans le domaine de la gestion de la faune, de la planification et de la foresterie. Le présent rapport a pu être terminé grâce au concours et aux encouragements de trois personnes : il s'agit de MM. Bruce Pendergast, Norm Sprout et Bob Marsh.

INTRODUCTION

"No one ever saw the old bear, but in the muddy springs about the base of the cliffs you saw his incredible tracks. Seeing them made the most hard-bitten cowboys aware of bear. Wherever they rode they saw the mountain, and when they saw the mountain they thought of bear....

"Since the beginning, time had gnawed at the basaltic hulk of Escudilla, wasting, waiting and building. Time built three things on the old mountain, a venerable aspect, a community of minor animals and plants, and a grizzly." From Escudilla, by Aldo Leopold.

Aims and Objectives

British Columbia has a wide diversity of ecosystems due to its large size (948 596 sq. km.), its position (bounded on the west by the Pacific Ocean and on the east by the Interior Plains and Rocky Mountains), its varied topography, and complex climatic patterns. These factors together provide an array of wildlife habitats which can be confusing to planners and wildlife managers. There are a number of strategies that organize ecosystem information

information depending upon objective or purpose.

Classifications have been developed to serve agricultural or forestry objectives, but these are not necessarily suitable for wildlife management. Animals respond to a broad combination of factors which provide for their habitat needs: these factors (biotic potential) relate to landform (physiography), climate (seasonal temperature extremes, mean temperature, total precipitation, and seasonal precipitation patterns, as well as snowfall parameters) (Leopold, 1933 and Edwards, 1956), plant community patterns, and stand structure (physiognomy). The distribution of an animal species is also affected by historic factors such as position of glacial refugeas or barriers to dispersal and migration. Not all of these factors can be mapped. Those that can be mapped include climatic processes, physiographic regions, and plant and animal distribution.

The aim of this project is to describe ecological requirements of terrestrial vertebrates at the strategic planning or regional level and at the provincial level. The project has three objectives:

1. To develop upper levels of the biophysical habitat classification system.
2. To define areas of similar biological potential.
3. To map those areas at a regional scale of 1:2 000 000 and a provincial scale of 1:5 000 000.
4. To describe the biological and physical parameters of each wildlife ecosystem appropriate to this level of detail.

Uses for the Wildlife Ecosystem Classification

Small scale (1:2 000 000) classifications of the province exist for geology, physiography, and flora. These classifications can provide information which is relevant for wildlife management; however, with the exception of the classification of biotic areas developed by Munro and Cowan (1947), none was designed to reflect the special needs of the province's wildlife resources.

The identification of wildlife ecosystems is accomplished by synthesizing physical and biological information into a single classification that reflects the ecological needs of relevant wildlife species. Such a classification would provide the following activities with a much better grouping of habitat information than has previously existed.

Biophysical ungulate capability mapping has been conducted at a scale of 1:50 000 in several parts of the province since 1975 and more recently at a scale of 1:250 000 in the northern part of the province (Demarchi et al., 1980 and Demarchi et al., 1983). To correlate the studies of each biophysical project, an overall provincial strategy for biophysical capability classifications should be developed.

If an ungulate species currently exists in an area, it is relatively easy to determine optimum habitats for ungulate capability mapping purposes. However, if an ungulate species does not now exist in an area, but adjoining areas have either expanding or decreasing populations, it is difficult to assess potential habitat use and carrying capacity. By synthesizing wildlife ecosystem information at a general level, the distribution and status of individual species can be better rationalized. Thus, population centers, and conversely population anomalies, can be identified at a provincial level.

The British Columbia Wildlife Branch has management plans for each of the big game species (including the ungulate species). Management programs, including species introductions, would be more easily rationalized if various populations were grouped on the basis of similar habitats or environments rather than by using distribution maps or administrative boundaries as a basis to identify management needs. Thus, the specific management requirements that must be dealt with for each species as they occur in various areas or regions of the province can then be related to broad-level parameters that influence each species. For example, mule deer that over-winter in the Fraser River "badlands" respond to different habitat factors than do mule deer in the aspen forests of the Peace River area or of the Douglas-fir forests of the East Kootenay.

Recently, the Assessment and Planning Branch and the Wildlife Branch of the Ministry of Environment have initiated a province-wide planning approach at a strategic planning scale (1:250 000) which will integrate broad-scale wildlife and other natural resource information. A description of wildlife ecological requirements as part of the regional wildlife ecosystem classification project would place strategic plans in a provincial perspective and provide at least a minimal coverage for wildlife in all of the province. This should overcome some of the data inadequacies that exist; much of the wildlife habitat management and habitat protection information that is available for strategic planning exercises has been collected on a piecemeal basis or at a variety of scales.

A REVIEW OF SOME EXISTING CLASSIFICATIONS

Existing Regional Ecosystem Classifications

Several regional classifications have been developed that have been used to stratify North America into areas that can be used to delineate wildlife/land units or ecosystems. Each has its positive attributes, but each also has shortcomings for application to a mountainous area such as British Columbia.

Lifezones as defined by C.H. Merriam represent transcontinental belts, expressed by both plants and animals but determined by temperature parameters. This classification emphasizes that temperature controls physiological activities of plants and animals more than any other parameter or interaction of parameters. Thus, factors such as moisture, topography, geological history, and species evolution are ignored (Smith, 1966).

Biotic provinces as defined by L.R. Dice are continuous geographic areas with definite ecological associations. It was an attempt to classify the distribution of plants and animals based on ranges and centers of distribution of various species and subspecies. Where the land mass is flat or uniform, the biotic provinces are broad and coincide with zonal plant formations; in the mountainous areas, the biotic provinces diminish in size and their boundaries become highly complex (Smith, 1966 and Udvardy, 1969).

Biomes as defined by F. Clements and V. Shelford are the largest land community unit that is convenient to recognize. Regional climates interact with regional biotic and substrates to produce large community units. Each biome consists of a distinctive combination of plants and animals in a climatic climax community and each is characterized by a uniform lifeform of vegetation, such as grass or coniferous trees. Biomes are identical with major plant formations as recognized by plant ecologists, except that the biome is a community of both plants and animals and not just plants. Also, every area having the same climax community, no matter how far from the main area of climax, belongs to the same biome (Smith, 1966 and Odum and Odum, 1959).

Biogeoclimatic zones as defined by V.J. Krajina are a climatic climax that is derived as the final successional product of the macroclimate which is 'controlling' a zone or its subzones. This classification is ecological in that it recognizes the interactions of environmental parameters, especially soil characteristics as well as biotic components; it was intended that organisms such as fungi, bacteria, insects, birds and mammals be as much a part of this classification as are the plants. However, in practice the classification only accommodates two components, vegetation and soils; thus, the classification characterizes each zonal ecosystem only by a plant community (an area of relatively uniform vegetation) and a soil polypedon (an area of relatively uniform soil) (Krajina, 1965 and Pojar, 1983). In addition, this classification is not really a regional classification, in that it would not deal with the complexity that occurs in this mountainous province. What are referred to as regions are actually zones; regional climates are actually zonal climates as inferred by selected plant species. Any complexity that arises is eliminated by creating new zones or subzones, rather than being incorporated into a region with a given level of complexity.

Biotic areas as defined by Munro and Cowan (1947) is a subdivision of the province into zoographical areas. Their system professes to stratify British Columbia on the basis of topographic, climatic, and vegetation parameters as they affect the distribution of terrestrial vertebrates. They used three major criteria in identifying a biotic area, namely the presence of distinctive plant species, the presence of animal species, and the absence of plant and animal species found in other biotic areas. Essentially, they have defined a zonal biotic area that is not unlike that for plant formations used in biotic province or biome classifications.

Ecoregions as defined by Bailey (1976) is a subdivision of the Unites States of America into ecosystem regions using a classification scheme proposed by Crowley (1967). This classification places great emphsis on climatic factors that relate to parameters as defined by Koppen (see Trewartha, 1943 and Thornthwaite, 1931). Also, the expression of climax vegetation is as a single climax formation (Bailey et al., 1985). The end result of which in a mountainous area like British Columbia, will be a zonation-like classification rather than a regional classification. Application of Crowley's (1967) definitions will therefore lead to vertical banding or zones, which is more appropriate at an operation level of management rather than at a planning or conceptual level of application.

The Canada Committee on Ecological Land Classification (CCELC) has developed a classification system for conducting an Ecological Land Survey (ELS) (Environmental Conservation Service Task Force, 1981). This is the program of identifying various components of any ecosystem (i.e. climate, terrain, hydrology, flora, and wildlife), including their relationships (e.g. time, processes, and systems). However, climate is inferred through the interpretation of vegetation distribution (Bailey et al., 1985) which, if drawn to its logical conclusion, will result in a zonation-like classification in a mountainous province. But, it is the lack of a well-defined methodology that makes it difficult to determine the organization of their stratification, i.e. which factors they considered first or to be most important. This classification also lacks wildlife population and distribution information as differentiating criteria.

Regional-scale, wildlife/land unit classifications have been developed for specified purposes and objectives. For the most part, each classification meets those objectives most of the time. However, some, like the life zone concept, lacked the necessary information to delineate all of the units; some, like biotic provinces and biomes, simplified the relationships between stand structure and animal diversity; and some, like the biogeoclimatic concept, superficially attempted to consider all component parts of the ecosystem but in practice concentrated on a limited number, such as plants and soils, and then assumed that these were indicative of the entire ecosystem.

If there is a single problem with applying any of these classifications in British Columbia it is that they do not simplify a mountainous ecosytem for the purpose of providing guidelines for wildlife management planning strategies. These classifications consider specific parameters that are useful in defining climatic climax communities, but they do not allow for a simple stratification of a complex mountainous environment.

Biophysical Classifications

In developing this regional wildlife ecosystem classification, a large number of physical, biological, and geographical works were consulted. The following identifies the sources of ecosystem information that were used in the development of this classification.

British Columbia is a land with a complex pattern of climates. Few attempts have been made to clarify the climate of the province. However, R.D. Marsh (1983) undertook a specific project to summarize the climate information such that it could be useful for this wildlife ecosystem classification project. He concentrated on classifying climatic processes, using climatic information only.

The climate of any particular area greatly affects the organisms and communities that develop there. Regions of similar large-scale climatological processes should be characterized by similar ecological communities where species differentiation and distribution within those regions respond to subregional temperature and moisture gradients. However, a macroclimatic process classification does not always identify all the parameters necessary to isolate regions that are pertinent to animals. For example, much of the Queen Charlotte Islands are influenced by the same climatic processes as the Kitimat Ranges. However, because of their insular nature, the Queen Charlotte Islands have the fewest number of animal species of any area in the province. Therefore, any wildlife ecosystem classification must use more information than is provided in a macroclimatic process classification by itself.

The province has been stratified on the basis of physiography based on landforms (Bostock, 1948) and with further refinement to include bedrock geology (Holland, 1964). A physical classification ignores climate and soil development processes; therefore, many of the subdivisions do not reflect all the factors that are relevant when determining animal or plant habitats or distributions. For example, the Coast Mountain subdivision does not reflect the extreme moisture deposition on the windward side and the decreased moisture and cooler temperatures on the leeward side. However, many of the macroclimatic processes that occur throughout the province are greatly influenced by physiographic features. Perhaps no other single feature or process has as much importance to the delineation of regional ecosystems in a complex topographical environment as does identification of physiographic units. The influence that these units have can be observed in climatic processes and parameters, vegetation distribution and development, and animal species distribution. Therefore, dominant landforms must be identified as an important step in the delineation of regional wildlife ecosystems.

The biogeoclimatic zonation concept as proposed by Krajina (1965 and 1972) and as implemented by the British Columbia Ministry of Forests (Pojar, 1983) is based on the premise that the vegetation of an area reflects the overall climate of that area. Within these climatic types, ecosystems may be identified according to varying soil conditions. A biogeoclimatic zone is an area having basically similar patterns of vegetation and soils as well as implied similarities of energy flow and nutrient cycling as a result of a broadly homogeneous climate. The biogeoclimatic zonation classification weighs heavily on climatic parameters, such as temperature, precipitation, and evaporation data. As a result, a given region is stratified elevationally into biogeoclimatic zones or subzones (Mitchell and Green, 1982). This system reflects the growth and abundance of dominant plant species (usually trees) and therefore offers only a partial perspective for animal ecology.

A stratification of the province into climax plant zones has merit for the management of vegetation and sedentary animal species such as amphibians, reptiles, and small mammals. However, because of their mobility, the larger species of mammals and birds are distributed within a seasonal cycle in many vegetation zones. Large mammals and birds are more likely to reflect general trends in environmental parameters, such as broad-scale climatic effects or physiography, and any changes in seasonal climate are usually met by behavioural responses such as hibernation, food storage, or migration, which, in the case of ungulates, is often from one vegetation zone to another. However, vegetation zonation classifications provide an interpretation of climate, physiography, soil, and botanical information that is useful in defining wildlife habitats, which in turn are useful in determining wildlife distribution and abundance.

CLASSIFICATION OF BRITISH COLUMBIA'S REGIONAL WILDLIFE ECOSYSTEMS

Definition of the Wildlife Ecosystems

To answer the aims and objectives outlined earlier, it is necessary to provide definitions of terms and concepts applied in organizing the ecosystem information.

An **ecosystem** is a volume of earth-space composed of non-living parts (climate, geologic materials, groundwater, and soils) and living or biotic parts, which are all constantly in a state of motion, transformation, and development (Odum and Odum, 1959). A **region** is a geographical area over which the ecosystem produced by macroclimate, relief, and soils is sufficiently uniform to permit the development of characteristic types of ecological associations (Bailey, 1976 and Hills et al., 1973). A **regional wildlife ecosystem** is an area that contains all the climax plant communities and their successional stages and all the wildlife populations that are influenced by a particular complex of macroclimatic processes over a large physiographic unit. The division of various regions into **sub-regional** units was necessary to reflect the variability of abiotic factors, such as physiography, that can occur within one regional wildlife ecosystem. Just as the identification of each **natural resource province** was necessary to show the common relationships that various wildlife ecosystems have with each other.

The regional wildlife ecosystem classification concept relies on the same philosophy that is applied in the more detailed biophysical classification approach that is used by the British Columbia Ministry of Environment (Walmsley, 1976 and Demarchi et al., 1983). To that end, the regional wildlife ecosystem classification provides an upper level to the biophysical habitat classification that Walmsley (1976) and Demarchi et al. (1983) state was not a hierarchical classification (see Table 1). Like the wildlife biophysical capability classification scheme, the regional wildlife ecosystem classification is designed to bring together ecological information in a form which will simplify the understanding of a wide array of wildlife/environmental relationships.

Table 1: Physical and biological parameters that are considered when defining habitat units at various levels in the British Columbia Ministry of Environment's Biophysical Habitat Classification.

CLASSIFICATION LEVEL	**SURVEY LEVELS AND COMMON MAPPING SCALES**	**PHYSICAL AND BIOLOGICAL PARAMETERS USED TO DETERMINE HABITAT UNITS AT VARIOUS SCALES**				
		Climate	**Terrain**	**Soils**	**Vegetation**	**Wildlife**
NATURAL RESOURCE PROVINCES	Provincial Overview 1:5,000,000	Macroclimatic Processes	Regional physiography	Soil Orders	Assemblages of vegetation regions and/or zones	Potential wildlife population ranges
WILDLIFE ECOSYSTEM REGIONS	Provincial Planning 1:2,000,000	Macroclimatic processes	Regional physiography; regional bedrock	Soil Orders	Vegetation regions (assemblages of vegetation zones)	Wildlife biogeography (historical and potential distribution or populations
ECOLOGICAL ZONES*	Regional or Strategic Planning 1:5,000,000 -1:2,50,000	Climatic regimes; macroclimatic parameters	Subdivision of regional physiography to represent groups of local landforms	Soil Great Groups	Climatic climax communities	Belts of seasonal use by migratory species
BIOPHYSICAL HABITAT UNITS	Reconnaissance, Capability Inventory 1:250,000 -1:50,000	Detailed mesoclimatic	Local landforms; topography (slope aspect); parent materials	Soil Subgroups, few classes (texture, depth chemistry)	Plant communities (potential successional stages, including climax)	Units of potential seasonal use by migratory species (usually ungulates or grizzly bears)
	Habitat Management, Detailed Inventory 1:20,000	Broad level microclimatic parameters	Specific landforms and materials, many classes	Soil series, many classes	Plant communities (succession, physiognomy)	Wildlife biology and the unfluence of social behaviour on distribution and habitat use
	Site-Specific Habitat Inventory 1:5,000	Microclimatic parameters	Materials	Phases of Soil Series	Plant communities many classes	Specific animal use (fish, waterbirds and macroinvertebrates)

* Ecological Zones are not available in British Columbia, but are listed as the ideal zonation description for wildlife. Biogeoclimatic Subzones, as identified by the B.C. Ministry of Forests, are substituted at this level; they are identified on the basis of climax communities and soil polypedons.

An alternative to the proposed method of first stratifying the landscape into provinces and then regions and subregions would have been to synthesize more detailed biophysical information into larger units. There exists sufficient biogeoclimatic and biophysical vegetation information that would enable habitat information to be grouped into larger units. However, the wildlife relationships for that information has not been determined. Also, there is a more fundamental problem in the application of the synthesis approach -- larger, diverse units encompass a complexity of environmental parameters and the combination of diverse yet adjacent units may not be rational from a classification point of view. What appears to be needed is the application of simpler concepts to define large, regional wildlife ecosystems as opposed to combining the more detailed information that is used to define specific wildlife habitats.

Both the wildlife ecosystem regions and the natural resource provinces, as drawn, represent units that are roughly homogeneous in terms of wildlife potential or productivity. Boundaries between two adjacent units are usually difficult to locate precisely -- there are few sharp distinctions in the environment and at any given scale there is a grading of one region's processes into those of another.

It was not the purpose of this classification to provide strict definitions of each unit. Firstly, there is not a sufficient body of knowledge that can be used to relate wildlife to all environmental parameters; secondly, there is a general paucity of wildlife and environmental information for most of the province. The approach taken can be justified on several grounds in that it is a statement of what is known about wildlife ecosystems in British Columbia and it will encourage further thoughts towards defining wildlife ecological relationships.

Application of the Wildlife Ecosystem Concepts

Classification of regional wildlife ecosystems is as a stepwise function that stratifies the more general factors first. The level of stratification should reflect those factors that are identifiable at the provincial level. Using remote sensing imagery and existing physical and biological information, the province was stratified into eight units or provinces, by delineating areas in which similar complexes of macroclimatic processes occur over common physiographic units. These units were further stratified into more detailed unites or regions, by delineating areas in which a similar complex of macroclimatic processes occur, and then by further stratifying those macroclimatic regions on the basis of physiography. Each boundary was then refined using climax community delineations (Figure 1).

If scale is temporarily forgotten or ignored, a confusion of detail or generalities can obscure the purpose of the line, that is, to bound an area of similar potential. Lines that represent two constrasting physiographic characteristics are more readily observable than are lines that represent a change in climatic processes or two physiographic units that are somewhat similar in character.

A subregion is a subdivision of a region or wildlife ecosystem which has the same macroclimatic processes as the region but has either a distinctive pattern of vegetation zones or a contrasting physiography. To be considered as a subregion, an area must be large enough that the wildlife populations that are present, while similar to those of the region as a whole, are in fact somewhat different from those of the region's.

All units were ultimately viewed from the perspective of delineating areas that were meaningful to wildlife and habitat management at specified planning levels. Units of similar relief but different macroclimatic processes were considered to be different to wildlife and habitat management and therefore were identified as separate units; units with a similar climatic process but with different relief or physiography were also judged to be different units.

Any regional habitat classification must at times be arbitrary and many compromises must be made. There are two main problems that have to be dealt with: small areas of unique physiographies; and, small areas with a unique complex of macroclimatic processes. At the provincial level, small areas of unique complexes of macroclimatic processes were identified with the adjacent unit which had the most processes in common. Where as, at the regional level, a small area of unique physiography that occurred along a political boundary and which had a unique physiography that was also represented by a larger unit in the adjoining territory, then that unique unit, was made into a separate sub-region. But, where a small, unique physiographic unit was within a region then no special status was given to it. Similarly, where a small area with a unique complex of macroclimatic processes occurred along a political boundary and those macroclimatic processes were represented by a larger unit was made into a separate region. However, where characteristic macroclimatic processes occurred over a small area and the area was completely within British Columbia, then it was designated as sub-region.

Careful consideration was given to the types of names that could be used for natural resource provinces and wildlife ecosystems; it was felt that names that best reflected the geographical area rather than the obvious vegetation or animal indicators would be most easily retained by the users. The natural resource provinces are named after the broadest regional geographic features; the names assigned to each region retain the name of the most dominant physiographic unit, while subregions are only identified by a letter.

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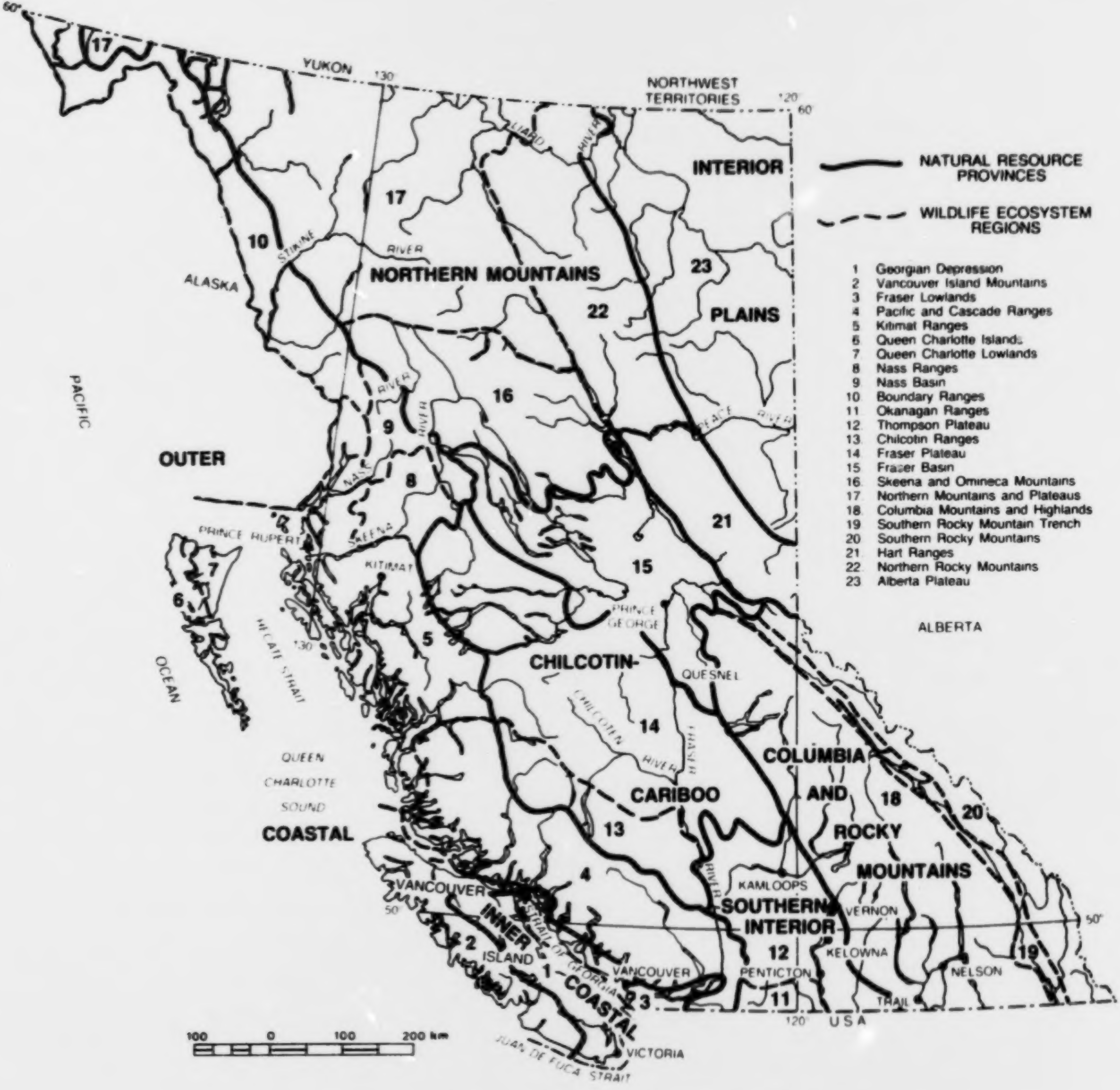
NATURAL RESOURCE PROVINCES
WILDLIFE ECOSYSTEM REGIONS
1 Georgian Depression
2 Vancouver Island Mountains
3 Fraser Lowlands
4 Pacific and Cascade Ranges
5 Kitimat Ranges
6 Queen Charlotte Islands
7 Queen Charlotte Lowlands
8 Nass Ranges
9 Nass Basin
10 Boundary Ranges
11 Okanagan Ranges
12 Thompson Plateau
13 Chilcotin Ranges
14 Fraser Plateau
15 Fraser Basin
16 Skeena and Omineca Mountains
17 Northern Mountains and Plateaus
18 Columbia Mountains and Highlands
19 Southern Rocky Mountain Trench
20 Southern Rocky Mountains
21 Hart Ranges
22 Northern Rocky Mountains
23 Alberta Plateau
YUKON
NORTHWEST TERRITORIES
ALASKA
PACIFIC
OCEAN
ALBERTA
USA
60°
130°
120°
50°
NORTHERN MOUNTAINS
INTERIOR PLAINS
OUTER COASTAL
CHILCOTIN-CARIBOO
COLUMBIA AND ROCKY MOUNTAINS
SOUTHERN INTERIOR
INNER COASTAL
VANCOUVER ISLAND
STIKINE RIVER
LIARD RIVER
PEACE RIVER
NASS RIVER
SKEENA
CHILCOTIN RIVER
FRASER RIVER
HECATE STRAIT
QUEEN CHARLOTTE SOUND
STRAIT OF GEORGIA
JUAN DE FUCA STRAIT
PRINCE RUPERT
KITIMAT
PRINCE GEORGE
QUESNEL
KAMLOOPS
VERNON
KELOWNA
PENTICTON
NELSON
TRAIL
VANCOUVER
VICTORIA
100 0 100 200 km

Figure 1. Wildlife Ecosystems of British Columbia.

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MACROCLIMATIC REGIONS OF BRITISH COLUMBIA

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ABSTRACT

This paper introduces a new approach to the differentiation of climatic regions in British Columbia. The methodology evolves from the need to provide a practical climatological framework to help delineate provincial Wildlife Ecosystems. Geographical areas are identified where the interactions of large-scale climatic controls with the underlying physiography of the Province are considered to be broadly homogeneous. This approach considers the physical, mechanical, and dynamic relationships between the atmosphere and the physiography of the province and should provide a meaningful framework for provincial climatological and ecological (biophysical) classification systems.

RÉSUMÉ

Ce rapport présente une nouvelle approche de différenciation des régions climatiques en Colombie-Britannique (Canada) : il s'agit de méthodes découlant du besoin de fournir un cadre climatologique pratique pour faciliter la délimitation des écosystèmes fauniques provinciaux. On identifie les régions géographiques où l'interaction des facteurs climatiques, mesurés sur une grande échelle, avec la physiographie sousjacente de la province est, estime-t-on, très homogène. Cette approche, qui tient compte des relations physiques, mécaniques et dynamiques entre l'atmosphère et la physiographie de la province, devrait fournir un cadre utile aux systèmes de classification climatologique et écologique à l'échelle de la province.

INTRODUCTION

This report examines climatological classifications and the typical use of descriptive climatology in ecological classifications. The need for a more holistic climatic classification for ecological applications is stated. A summary of the relationship of climate to ecological systems is presented. The report defines climate and briefly examines climate as a paradox - an entity which lacks any distinct point of demarcation in either space or time. The concept of macroclimatic processes and Regions is discussed and thirteen climatic regions of the Province are described individually in terms of the macroclimatic processes which give them their overriding climatological character.

CLIMATE AND ECOLOGICAL CLASSIFICATION

The classification of climate has been a human consideration since the days of ancient Greece. However, more sophisticated classifications did not exist until the early 20th century when W. Koppen (1918) attempted to describe world climates by identifying areas where there was a relative homogeneity of climatic elements. More recently C.W. Thornthwaite (1931, 1948) used indexes of climatic elements such as thermal efficiency and precipitation effectiveness to produce a bioclimatological classification.

Such classifications can be climatologically instructive but are not universally applicable for ecological mapping and other interpretations. Climatological classification criteria may be selected to reflect the distribution of a particular ecosystem component, such as vegetation. These criteria, however, are parochial since other components of the same ecosystem may require the use of alternate selection criteria. Since element-based classification criteria lack universality of application, and since the climatological data base in the Province is insufficient to delineate predetermined spatial thermal and moisture thresholds with an acceptable degree of reliability, the development and application of a practicable and universal element-based climate classification for resource management in British Columbia is not yet feasible.

To the present time, ecological classifications have identified climatically significant ecological units, not by quantifying climatological elements and parameters, but rather by using vegetation as both an intergrator and indicator of local and regional climate. Once the vegetation zones were delineated the climates corresponding to those units were described. Climate, therefore, served as a descriptor, rather than a delineator, of an ecological unit.

A more holistic approach was felt necessary in differentiating climates for purposes of delineating Wildlife Ecosystems. Intuitively it is recognized that the areal extent and diversity of discrete Wildlife Ecosystems is determined and regulated by the distribution of heat and moisture; the truly active climatological factors. Rather than identifying specific climatic elements which quantify the geographic distribution of heat and moisture thresholds, the active processes of climatic control which determine the absolute distribution of heat and moisture, were identified. The geographic area over which a characteristic combination of climatic processes occur, identifies a macroclimatic region and this region, in turn, serves to delineate the broadest extent of a Wildlife Ecosystem. Within macroclimatic regions heat and moisture gradients will occur which, if quantified, will aid in identifying ecological sub-regions and zones.

The demarcation of Wildlife Ecosystems is not intended to be a system of classification but rather a practical means of integrating, understanding and interpreting a wide array of biophysical and ecological inter-relationships (Demarchi, 1984). This is directly analogous to the differentiation of macroclimatic regions which is a practical, interpretative, process-oriented method of partitioning the climate of the Province into manageable and meaningful units. It is not intended to be a rigorous system of classification, although with sufficient synoptic meteorological data this would be possible.

In this report macroclimatic regions have been identified through the interpretation of physiographic information (Holland, 1964), abstraction of published synoptic analyses (Maunder, 1968; Suckling, 1977) and through the use of subjective interpretations based on the author's practical climatological experience throughout the Province. The regions have been delineated solely on the basis of macroclimatic processes and in the delineation of these units the areal distribution of regional vegetation was not considered.

There is an exceptional correspondence between ecological units which are derived using vegetation or wildlife as regional indicators, and the macroclimatic regions which are derived using only the non-living components of the ecosystem. This should come as no surprise since the consideration of regional physiography, actual or implied, is common to both approaches. The influence of physiography, on either approach, is great. Demarchi (1984) has stated that "Perhaps no other single feature or process has as much importance to the delineation of regional ecosystems in a complex topographical environment as does identification of physiographic units."

CLIMATE AND ECOLOGY

The climate of the past has influenced the distribution of existing ecological communities through glaciation and weathering of the earth's mantle to create soil parent materials. Climatic factors influence the rate of formation of the chemical and biological mantle weathering complex which consists of soil parent materials, micro-organisms, and plants.

Every part of the temporal weather continuum has influenced existing ecological communities to some extent through the impact of weather on soil and plant development. However, the day to day partitioning of heat and moisture during the more recent past has had a greater immediate impact on the distribution of existing flora and fauna and on the present nature of ecological communities. If management strategies are to be identified for existing biological resources, it is the climate of the recent past which must be considered in that planning process. Not only does this serve to identify the 'present-day' climate on the temporal weather continuum but also serves to represent the likely climate of the near future.

Ecology is that branch of science which deals with the interrelationship of organisms and their environment. A complex of climatic, edaphic, and biotic factors act upon organisms and ecological communities to influence their form and determine their survival. The basic unit of ecology is the ecosystem which is a complex of both living organisms and the non-living environment; each influencing the properties of the other and both necessary for the maintenance of life. Hare and Thomas (1974) observe that if a specific set of soils and vegetation types are usually associated with a given climate, their must be some system of interaction that keeps the ecosystem in being. This sytem of interaction is bioclimate; bioclimatology being the study of climate-life links of the ecosystems.

A Wildlife Ecosystem is a large geographical area which contains the climax plant communities, their successional stages, and the wildlife populations which are influenced by a common macroclimate (after Demarchi 1984). The need to delineate Wildlife Ecosystems throughout the Province requires that 'common' macroclimates first be identified. This raises the involuted question of what universal macroclimatic characteristics will serve to demark discrete Wildlife Ecosystems?

THE NATURE OF CLIMATE

An acceptable definition and intuitive understanding of climate are required before any practical climatic classification can be developed. This can be difficult since climate cannot be perceived directly by the senses. Climate has been defined as 'the long-term manifestation of weather', 'a synthesis of the weather' or more precisely 'the statistical collective of weather conditions during a specific interval of time' (American Meteorological Society, 1959). These definitions indicate the close relationship between climate and weather but remain lacking since 'the climate' of an area represents but a portion of a continuum of weather which varies in both time and space. Weather is the existing state of the atmosphere as determined by the simultaneous occurrence of several meteorological phenomena over a short period of time. Climate can be defined as the mean physical state of the atmosphere together with its temporal and spatial statistical variations which reflect the totality of weather behaviour over some specific period of time.

Weather, and therefore climate, results from the intimate and dynamic interaction of the lower atmosphere with the surface of the earth. A massive and continuous two-way flux of energy and moisture occurs over the atmosphere/earth interface. Radiation from the sun provides the energy to warm the earth surface and to drive the hydrologic cycle. There is an exchange of thermal energy as the earth's surface warms or cools the lower layers of the atmosphere by conduction, convection and radiation. Large amounts of energy are exchanged as water is evaporated from the earth surface and transported into the atmosphere. As this water vapour is condensed, the troposphere is warmed and the moisture returned to the earth.

The temperature, moisture content, and density of the lower layers of the atmosphere are determined in part by the physical and thermodynamic characteristics of the earth surface. Individual parcels of air are formed and dispersed as atmospheric currents move over physically and thermodynamically diverse surfaces of the earth. This mechanism not only gives the atmosphere a complex and turbulent structure but serves to transport heat and moisture from one part of the earth to another. Every discrete unit of the earth's surface has some impact on weather and climate because of the dynamic exchange of energy and moisture with the atmosphere. However, the relative impact is dependent on the nature of the earth surface (terrestrial, or water) and proportional to the areal extent of the unit of earth being considered.

Fine climatic structures (microclimate) exist in the air space above both an ant hill and a football field and extend to a distance and height where the influence of the underlying surface is indistinguishable from that of the local area. Similarly, the climate of local areas such as small valleys, individual mountains, and frost hollows (mesoclimates) extend from the earth surface to a distance and height where the influence of the underlying surface becomes indistinguishable from that of the region. The climate of regions and large geographic areas are macroclimates. It is apparent that micro, meso, and macroclimates are merely different parts of the same spatial continuum of weather and that microclimates collectively influence the character of regional climates.

Climatic controls are the relatively permanent astrophysical, atmospheric, and geographical factors that govern the nature of the climate of any particular part of the earth. These factors include solar radiation, the distribution of land and water masses, ocean currents, large scale topography, the general circulation of the main wind systems, and the movement of air masses. Climatic controls are sufficiently regular and permanent to always bring the weather back toward the seasonal normal after temporary departures and make possible the existence of definable types of climate. In this report the mechanical and thermodynamic interaction between climatic controls are referred to as macroclimatic processes.

MACROCLIMATIC PROCESSES OF BRITISH COLUMBIA

The combined influence of differential heating of land and ocean masses and the spin of the earth has created a general circulation in the earth's atmosphere. This circulation is characterized by a number of latitudinal belts; one being the prevailing westerly winds which influence British Columbia and most of the rest of Canada.

With the prevailing westerly winds the general movement of the upper air is from west to east. Low and high pressure areas move across Canada embedded in the westerlies stream, their movement associated with the hemispheric confrontation between southward flowing cold air and northward flowing warm air. In winter, cold high pressure areas dominate the interior of the continent and relatively warm low pressure areas dominate the coastal areas. In summer this pattern is reversed with a large semi-permanent high pressure area over the north Pacific dominating the general circulation in western Canada. During the summer, frontal systems strike the Pacific Coast further north and with reduced frequency (Chapman, 1952; DOT, 1962).

The rugged relief of the Western Cordillera has a great effect on the climate of western Canada. The Coast Mountains limit the mild, humid Pacific air to a narrow band along the coast. As air is forced to rise over successive mountain ranges (orographic lifting) its moisture is precipitated on windward slopes. The Rocky Mountains commonly block westward-moving outbreaks of cold Arctic air. Southward-moving Arctic air from the Yukon and northern British Columbia is impeded only by the Coast Mountains and so moves into the interior of the Province. Occasionally, under strong outflow conditions, outbreaks of Arctic air reach coastal areas by way of the major river valleys.

To a very large degree, macroclimatic processes in British Columbia are dominated by the physiography of the underlying Province; the physiography being oriented northwest to southeast and generally perpendicular to the prevailing westerlies. Windward slopes of mountain ranges are areas of rising air which leads to cooling, increased relative humidity, moisture condensation and precipitation. Leeward slopes are areas of descending or subsiding air which are typified by warmer, drier conditions. Plateau areas exhibit summertime precipitation patterns which result from surface heating which leads to convective showers. Physiographically dominant valleys are subject to broad scale valley processes which result from intense surface heating, cold air pooling, and topographically induced rainshadow effects. A macroclimatic region is defined as a geographical area which is influenced by a common set of macroclimatic processes.

Within a macroclimatic region the characterizing processes may vary in intensity, frequency or persistency. The interaction of macroclimatic processes in these situations may be expressed by subtly different climates within regions which can be delineated and defined as macroclimatic sub-regions.

Within macroclimatic regions and sub-regions the characteristic processes result in a complex of thermal and precipitation gradients. Such thermal and precipitation regimes are reflected by the diversity and distribution of flora and fauna and can be quantified by climatological data of sufficient resolution. Where these regimes are diverse, the unit can be further subdivided into zones using either generalized descriptive criteria, such as warm-dry/cool-wet, or predefined thresholds of quantifiable climatological parameters.

MACROCLIMATIC REGIONS OF BRITISH COLUMBIA

Region 1 - Pacific Coast

The Pacific Coast region extends the complete length of British Columbia and the Alaskan Panhandle from the Pacifc Ocean to the Coast Mountain Divide. In the extreme northwest corner of the Province the eastern boundary is the height of land along the St. Elias Mountains Fairweather Ranges. A relatively small portion of southwest coastal British

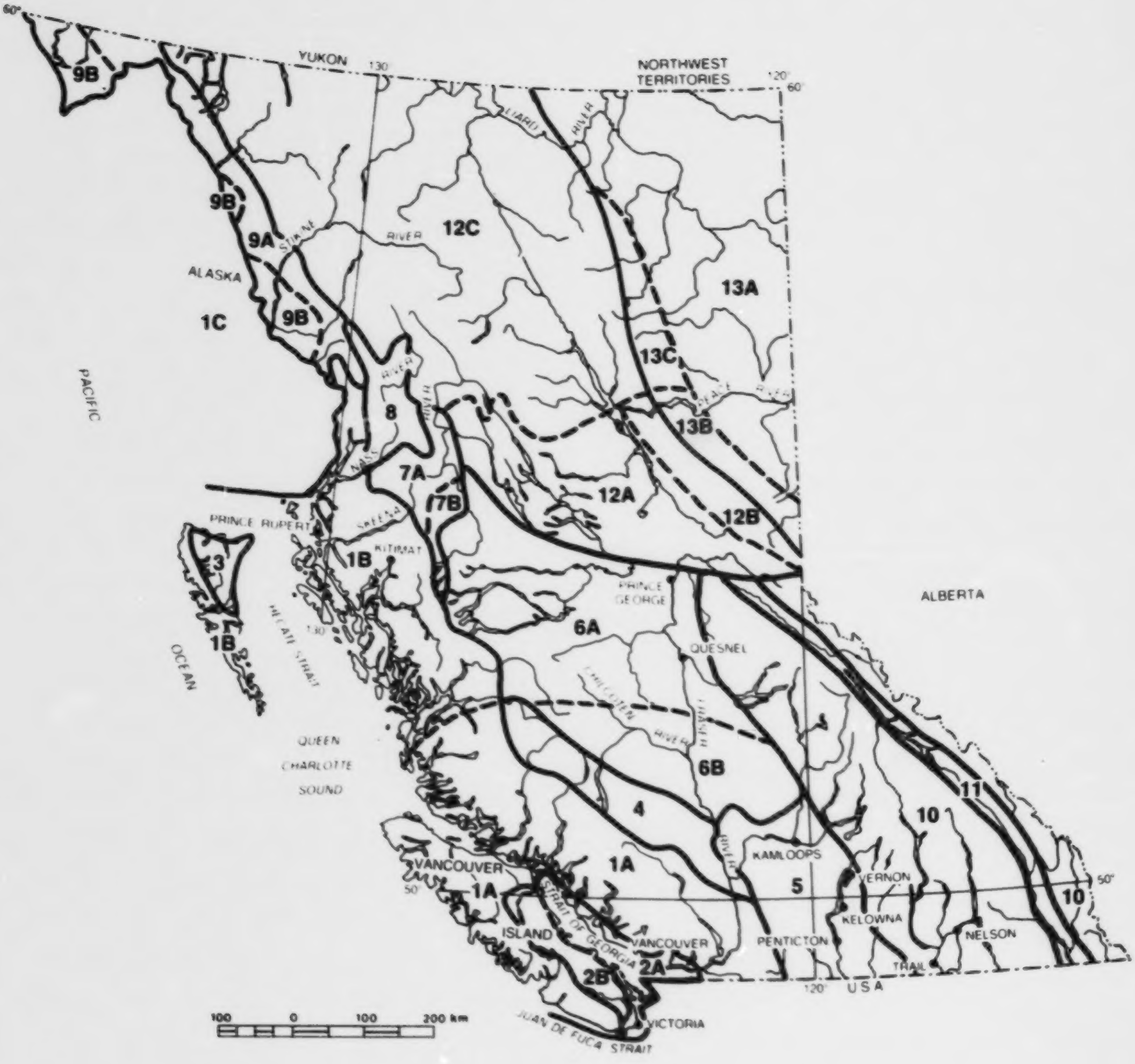
60°
YUKON
130°
NORTHWEST
TERRITORIES
120°
60°
9B
LIARD
RIVER
9B
9A
STIKINE
RIVER
12C
ALASKA
1C
9B
13A
PACIFIC
13C
PEACE
RIVER
RIVER
8
NASS
13B
7A
7B
12A
12B
PRINCE RUPERT
SKEENA
KITIMAT
1B
3
1B
OCEAN
HECATE STRAIT
130°
PRINCE
GEORGE
ALBERTA
6A
QUESNEL
CHILCOTEN
RIVER
FRASER
QUEEN
CHARLOTTE
SOUND
6B
4
10
11
1A
KAMLOOPS
RIVER
VANCOUVER
50°
1A
STRAIT OF GEORGIA
5
VERNON
50°
10
KELOWNA
ISLAND
VANCOUVER
PENTICTON
NELSON
TRAIL
2B
2A
120°
USA
100
0
100
200 km
VICTORIA
JUAN DE FUCA STRAIT

Figure 1. The Macroclimatic Regions of British Columbia

Columbia is excluded from this region as there exists a significant difference in macroclimatic processes (see Region 2). The major processes in Region 1 are the movement of frontal systems onto the coast from over the Pacific Ocean and the subsequent lifting of these systems over the coastal mountains.

A wide variety of pressure systems move onto the coast and over the Province; highs, ridges, lows, and troughs. Some systems are more persistent than others and as such have a greater relative impact on the physical and biological resources of the region. In winter, oceanic low pressure systems dominate and pump moist, mild air onto the south and central coastal areas. Under these conditions, the Alaskan coast is commonly subjected to colder, drier conditions as air from the Yukon and Alaska interior flows over the area either directly or after a short trajectory over the north Pacific Ocean. Fall and winter are often associated with the progression of frontal systems down the coast (Shaefer, per. com.). In summer, high pressure systems occur over the north Pacific Ocean and frontal systems become less frequent and tend to strike the coast over Alaska and north central British Columbia.

Coastal subregions 1A and 1C (see map in Section 8.1) are defined by differences in pressure system frontal frequency and seasonality. These differences are due to the geographic location of these subregions relative to the North Pacific high pressure area in summer and the Aleutian low in winter.

Coastal subregion 1B is more complex representing a transition area between subregions 1A and 1C. Even though characterized by the typical heavy rainfall in response to orographic lifting, the process is less intense due to a significantly lower Coast Mountain barrier betwen 52 and 55 degrees north latitude. This gap provides the path of least resistance for surface air flow associated with many frontal systems.

Region 2 - Dry South Coast

Region 2 extends from the southern tip of Vancouver Island and the lower Fraser Valley to 50°10' north latitude and from the eastern slopes of the Vancouver Island ranges of the Insular Mountains to the eastern edge of the Georgia Lowland.

The Dry South Coast is characterized by a particularly effective rainshadow leeward of the Vancouver Island Range of the Insular Mountains and the Olympic Peninsula of the Coast Mountains. After moving over these mountain barriers, surface air flow is level or subsiding and leads to clearer skies and drier conditions. The southern parts of this region are the sunniest in British Columbia on an annual basis. Temperatures throughout the region are moderated by the close proximity of the Pacific Ocean.

Subregion 2B is subjected to the same macroclimatic processes but is wetter and cloudier because of its higher elevation and increased exposure to moist air from the outer coast by way of the lower mountain passes. Orographic lifting along the eastern slopes of the Insular Mountains occurs when pressure systems bring southeasterly winds to the region.

Region 3 - Queen Charlotte Lowlands

Region 3 extends over the northeastern portion of the Queen Charlotte Islands from the eastern slopes of the Insular Mountains to the Hecate Strait. Generally it can be delineated by a line running from Gray Bay, on northeast Moresby Island, to the western end of Masset Inlet and Seath Point on northwest Graham Island.

In this region the macroclimatic processes are the same as those in Region 1 except that orographic lifting is replaced by a level or slightly subsiding surface air flow and macroclimatic rainshadow effects dominate under particular synoptic conditions.

Zones can be identified within Region 13 which reflect the variability in rainshadow intensity which is in turn a reflection of the frequency and persistency of pressure systems and their associated surface wind flow.

Region 4 - South Mountain Transition

Region 4 extends from the Coast Mountain Divide east to the western edge of the Interior Plateau and from 49°50' north latitude to 52°30' north latitude.

The area is a difficult one to typify since there is an interplay of macroclimatic processes over a mountainous topography. Generally this is an area of orographically subsiding air leeward of the Coast Mountain height of land and an area subjected to variable rainshadow effects. Although generally dry, extreme western areas can receive much rainfall as carryover from the orographic lifting process and local areas are subjected to higher precipitation where moist coastal air pushes through the lower mountain passes. During the winter and early spring, Arctic air frequently stalls on the eastern edge of the Region at higher and mid altitudes, but pushes some distance into the major valleys at the lower altitudes.

Region 5 - Dry Interior

This region encompasses the southern portions of the Interior Plateau, south of 51° north latitude to the Washington border. In the summer the warmest, driest parts of British Columbia occur in this area - largely as a consequence of the location of the area leeward of the Coast and Cascade mountains. Air moving into the Region from the west is dried by orographic subsidence and as a consequence skies tend to be more cloud-free than other areas of the Province, particularly during the summer months.

The Region is subjected to frequent outbreaks of Arctic air during the winter and early spring because there is no effective northerly barrier to prevent such an occurrence. However, the frequency of occurrence of Arctic air is less than that over plateau areas to the north.

Region 5 is topographically more complex than the rest of the Interior Plateau. The annual distribution of precipitation is similar to other interior plateaus in British Columbia and surface heating, which results in convective showers, is characteristic of summer precipitation processes. However, the presence of valleys such as the Thompson, Nicola, Okanagan and Similkameen influence the regional character of the climate. These are areas of higher surface temperatures, enhanced convective currents and sources of readily available moisture. Valley climates reflect increased precipitation over the surrounding hills while skies over these valleys tend to be more cloud free particularly during the warm summer months. In winter, arctic air filling such valleys can be capped by warmer, moister air of Pacific origin leading to deep inversions and prolonged periods of cold weather at mid and low altitudes and milder conditions at both higher altitudes and areas away from the valleys. During the warm months, hot, dry air from the Great Basin of U.S.A. occasionally advects into the area from the southeast bringing clear skies and very warm temperatures.

Region 6 - Central Interior

Region 6 extends over a large portion of the Central Plateau, from the eastern edge of the Coast Mountains to the western edge of the Columbia Mountains, and from the northern edge of the Thompson Plateau in the south to a line extending diagonally across the central interior between New Hazelton and Prince George.

Typically this is an area with a continental climate; cold winters, warm summers, and a precipitation maximum in late spring or early summer. However, the moderating influences of Pacific air occur throughout the year, as is the case for most of British Columbia south of 57° north latitude.

Dominant macroclimatic processes in this area are orographically subsiding air leeward of the Coast Mountains, plateau related processes such as intense surface heating and convective showers, frequent outbreaks of Arctic air during the winter and spring (although less frequent than areas to the north) and, under certain synoptic conditions, the advection of moderated and humid Pacific air into the Region by way of the Coast Mountain gap.

Subregion 6A exhibits a reduced rainshadow effect because of its position immediately east of the Coast Mountain gap and consequently reflects a greater influence of Pacific air through increased precipitation and smaller west-east precipitation gradients.

Subregion 6B delineates a better defined rainshadow region and in this respect it is less affected by the existence of the Coast Mountain gap located to the north west.

Region 7 - Central Mountain Transition

Region 7 generally encompasses the Hazelton Mountains of the Central Plateau and the lower reaches of the Bulkley River Valley.

The dominant macroclimatic process of this region is the prevailing flow of Pacific air which has been previously lifted and partially dried by its passage over the Kitimat Ranges of the Coast Mountains. This air is neither lifting nor descending during its passage over the area and moderate amounts of moisture are precipitated. At low elevations local rainshadows occur where river valleys are oriented perpendicular to the flow of air. During the winter and early spring, Arctic air occasionally stalls along the eastern edge of the Region. Less frequently, deep outbreaks of Arctic air push towards the coast along the Skeena River valley and may overrun the entire area.

The climate of subregion 7A exhibits a stronger coastal influence, more pronounced transitional gradients and generally is an area of interaction between coastal and interior air masses.

Subregion 7B exhibits a stronger interior climate and is subjected to a greater frequency of Arctic air during the winter. This is especially true in the southern areas over the lakes and valleys of the Morice, Nanika and Nechako drainages.

Region 8 - Nass Basin Transition

Region 8 closely approximates the physiographic boundaries of the Nass Basin and as a consequence is an area of restricted width and low relief.

The dominant macroclimatic process is the flow of moist coastal air into the area from the Coast Mountain gap in the southwest along the Nass River Valley. The Coast Mountains contribute to the partial drying of Pacific air before it is advected into the area but the height of these windward mountains is inadequate to provide an effective moisture barrier for the region. Leeward of these mountains there is little subsidence of Pacific air because there is low elevation access to the Region along the Nass River depression, the Region is relatively narrow, and because orographic lifting begins again on the eastern edge of the area where the surface air encounters the Skeena Mountains. The Pacific air flow tends to be topographically directed southwest to northeast through the area.

This area is subjected to frequent outbreaks of Arctic air during the winter months. Particularly strong outbreaks rush through the Region to the coast by way of the Nass River valley. Typically this is an area of confrontation between coastal and interior air masses although coastal influences dominate throughout the year. In winter, coastal systems moving into the Region can override cold Arctic air lying in the basin and will often result in increased snowfall. This is particularly true in the northern half of the region.

Region 9 - Northern Mountain Transition

Region 9 extends from the Cambria Icefield in the south to the Yukon border and from the Fairweather Range and Coast Mountain divides in the west to the western edge of the Central Plateau.

Orographic subsidence is the major macroclimatic process in this region. Along the western edge of the area the Coast and St. Elias mountains are high enough to be an effective moisture barrier and air descending the leeward slopes becomes drier. Arctic outbreaks are common at this latitude during the winter and spring months and such air masses are generally restrained along the eastern edge of the Region.

Subregion 9A exhibits a more interior climate, tending to be colder and drier due to the height of the westward lying mountains.

Subregion 9B reflects influences from a north coastal climate since surface coastal air gains access to the area along some of the larger river valleys which transect the Coast Mountains. Precipitation is greater in this subregion and temperatures are more moderate. These corridors also provide access to the coast for Arctic air when such outbreaks are strong enough to displace the coastal air.

Region 10 - South Interior Mountain

Region 10 corresponds exactly with the physiographic boundaries of the Columbia Mountains and the Rocky Mountains south of 53°40' north latitude. The Rocky Mountain Trench is not considered to be a part of this Region.

Although there are strong temperature and precipitation gradients over the area, the macroclimatic processes are largely the same. Orographic lifting typifies the western half of Region 10 and a horizontally stable air flow characterizes the eastern portions. Orographic lifting occurs again as the air encounters the Rocky Mountains along the eastern edge of the area. The moisture precipitated over the Region is obtained from three main sources; from the coast by way of the lower passes of the southern parts of the Coast Mountains, from the coast in larger quantities by way of the Coast Mountain gap during some synoptic conditions, and from evaporation from the surface waters and transpiration of vegetation on the Interior Plateau. Surface water within the Rocky Mountain Trench provides a minor source of precipitable water for the Rocky Mountain portion of Region 10.

Outbreaks of Arctic air occur occasionally throughout the winter. Most commonly these outbreaks pass into the area from the Rocky Mountain Trench along the Duncan, Kootenay and Columbia river systems. The Kootenay region is usually the last place in the Interior of British Columbia to be overrun by Arctic air when such events occur (Tyner, 1951).

Region 11 - South Rocky Mountain Trench

This region is situated between the Columbia and Rocky mountains and extends from the northern border of Montana, U.S.A., to 53°50' north latitude.

Although this area bisects Region 10, the physiography and macroclimatic processes are significantly different. A strong rainshadow effect exists leeward of the Columbia Mountains in this portion of the Rocky Mountain Trench. During the warm half of the year, intense surface heating creates strong upslope convective currents which induces subsidence over the centre of the valley. This process enhances the sunny, warm, dry conditions which characterize the summer climate of this region.

During the winter and early spring months this portion of the Trench serves as an access route for cold Arctic air when such outbreaks occur. As a result, it is subject to a greater frequency of more intense outbreaks than areas in Region 10.

Region 12 - North Central Interior

Region 12 extends from the eastern edge of the Coast Mountains to the western edge of the Rocky Mountain Foothills and from 54° north latitude to the British Columbia - Yukon border.

Prevailing westerly winds bring Pacific air to the region over the Coast Mountains by way of the Coast Mountain gap or the Alaska Panhandle, or over the St. Elias Mountains in the north west depending upon prevailing synoptic conditions. Although coastal air is greatly reduced in moisture when it reaches this northern plateau country, considerably more moisture passes into the area with a southwest flow of air through the Coast Mountain gap.

The Region is characterized by orographically subsiding air leeward of the major mountain ranges along the Pacific coast. Summertime surface heating leads to convective showers and together with winter frontal systems result in precipitation amounts which are evenly distributed throughout the year.

Outbreaks of Arctic air are frequent during the winter and spring, the cold air moving largely unhindered from the north to the south over the area. The southern edge of Region 12 represents the estimated average southern extent of the Arctic air mass in January and is a line which represents the location of the Arctic air mass commonly observed by operational meteorologists (Shaefer, per. com.).

Subregion 12A is physiographically more similar to Region 6 than the rest of Region 12. However, macroclimatic processes have provided the rationale for the division as it presently exists. Subregion 12A is situated at a latitude which is at or above the northern limit of the Coast Mountain gap. With a northwest flow of air from the Pacific, 12A receives less precipitable moisture than areas to the south. Conversely, with a southwest flow 12A receives more moisture. Subregion 12A is subjected to a greater frequency of Arctic air than the plateau areas to the south.

Subregion 12B is subject to the same synoptic systems as the rest of region 12, but is characterized by the orographic lifting of Pacific air masses as they pass over this part of the Rocky Mountains. Here the relief is considerably reduced from that of Rocky Mountain areas to both the north and south. Twelve B also serves as the access route to the interior of British Columbia for Arctic air masses which flow in from the northeast.

Subregion 12C represents the mountainous portions of the northern Interior Plateau. Some of the area is very dry due to subsiding air and rainshadow effects leeward of the Coast and St. Elias mountains. At the eastern edge of the region, air is orographically lifted over the northern Rocky Mountains, but the air is relatively dry and orographically induced precipitation is not excessive.

The southern part of 12C is an area of increased precipitation when air flow is south westerly. Under these conditions, mild, moist Pacific air flows over the Coast Mountain gap and much of the remaining moisture is precipitated as the air rises from the lower plateau areas over the Skeena and Omineka mountains. When Arctic air is lying over region 12 the warmer southwest Pacific flow will ride up and over the wedge of colder air. The rising Pacific air will cool, water vapour will condense, and precipitation will fall through the underlying Arctic air in the form of snow. Hence, the southern part of 12C is an area of relatively high snowfall. As the Pacific air flows northward it is progressively dried so that the northern part of 12C receives very little extra moisture under these conditions.

Locally, subregion 12C differs from 12A because the more rugged relief leads to a more complex pattern of surface heating and cold air drainage. However, despite the fact that this area is more sheltered from the moist Pacific air, the large scale climatological processes are similar.

Region 13 - Alberta Plateau and Foothills

Region 13 extends diagonally across the northeast corner of British Columbia and encompasses all parts of the province east of the Liard Plain and the western edge of the Rocky Mountain Foothills.

The climate of the region is typically continental since most of the moisture has been wrung out of Pacific air masses by the time they reach the area. Air is orographically descending from the Rocky Mountains leading to generally drier conditions and sunnier skies. There is no barrier to southward and westward moving Arctic air so the region is subjected to a high frequency of such events.

Precipitation is light and in the warmer months is largely due to surface heating which leads to convective showers. Under some synoptic conditions, stalled low pressure systems (cold lows) located over western Alberta push moist southern air up the east facing slopes of the Rocky Mountains and Foothills. Through this orographic lifting process heavy amounts of moisture are precipitated on these slopes. Many of the extreme rainfall events in the region resulted from this kind of process.

Subregions 13B and 13C differ from 13A due to more complex and rugged topography. Although the major synoptic climatological processes are similar, orographic lifting becomes a dominant process when cold lows prevail. These subregions are influenced by cold lows to a greater extent than the rest of the region because of greater elevations and steeper relief.

Subregion 13B is subjected to a slightly more moderated flow of Pacific air since this is the eastern side of the Rocky Mountain gap. Under conditions of Westerly flow this area may receive more precipitation than the rest of the region, especially along the lower passes.

SUMMARY OF REGIONAL MACROCLIMATIC PROCESSES

Region 1 - Pacific Coast
- seasonally shifting storms track
- impingement of frontal systems
- orographic lifting

Region 2 - Dry South Coast
- rainshadow effects
- level or gently subsiding air flow
- occasional orographic lifting

Region 3 - Queen Charlotte Lowlands
- seasonal shifting storm track
- impingement of frontal systems
- rainshadow effects
- level to gently subsiding air flow

Region 4 - South Mountain Transition
- level to orographically subsiding air flow
- variable rainshadow effects
- variable occurrence and depth of Arctic air

Region 5 - Dry Interior
- rain shadow effects
- orographic subsidence
- seasonal occurrence of Arctic air
- regionally manifest valley effects
- occasional advection of continental Tropical air

Region 6 - Central Interior
- variable rainshadow effects
- orographic subsidence
- regionally manifest plateau processes (convective showers)
- frequent seasonal occurrence of Arctic air
- advection of Pacific air

Region 7 - Central Mountain Transition
- level air flow
- local rainshadow effects
- some seasonal occurrence of Arctic air
- common occurrence of Pacific air

Region 8 - Nass Basin Transition
- advection of moist, mild, Pacific air
- level air flow (neither lifting or subsiding)
- occasional occurrence of seasonal Arctic air

Region 9 - Northern Mountain Transition
- orographic subsidence
- variable rainshadow effects
- common seasonal occurrence of Arctic air
- variable influence from north coastal surface air

Region 10 - South Interior Mountain
- orographic lifting
- occasional seasonal occurrence of Arctic air

Region 11 - South Rocky Mountain Trench
- rainshadow effect
- regionally manifest valley processes (surface heating, subsidence, convective showers, etc.)
- common seasonal occurrence of Arctic air

Region 12 - North Central Interior
- variable advection of coastal air
- orographic subidence
- seasonal surface heating and convective showers
- frequent seasonal occurrence of Arctic air
- variable influence from frontal lifting of Pacific air

Region 13 - Alberta Plateau and Foothills
- orographic subsidence
- frequent occurrence of Arctic air
- common occurrence of cold lows
- occasional orogrphic lifting (with cold lows)

DEFINITIONS

advection - the process of transport of an atmospheric property solely by the mass motion of the atmosphere; the horizontal large-scale motions of the atmosphere.

arctic air - a type of air whose characteristics are developed mostly in winter over arctic surfaces of ice and snow.

biophysical - the biological and physical attributes of the landscape.

climatic controls - relatively permanent atmospheric and geographical factors that govern the general nature of the climate of any part of the earth.

Coast Mountain gap - represented by the Kitimat Ranges of the Coast Mountains. Consists of round-topped mountains which in general are 1000 feet lower than the Boundary Ranges to the north and 3000 feet lower than the Pacific Ranges to the south.

cold low - any low pressure area which is generally characterized by colder air near its centre than around its periphery. In this report refers to a cold low with a completely isolated pool of cold air at its vortex.

continental climate - the climate that is characteristic of the interior of a land mass of continental size. Typified by large annual and daily temperature range, low humidity, and low irregular rainfall.

continental Tropical air - a type of air mass whose characteristics are developed over low latitudes, specifically over subtropical arid regions.

continuum - something absolutely continuous and homogenous of which no distinction of content can be affirmed except by reference to something else (as duration).

convective - adjective describing the vertical atmospheric motions which result in transport and mixing of atmospheric properties.

high pressure area - an area subject to a maximum of atmospheric pressure in two dimensions on a synoptic surface chart.

hydrologic cycle - the composite picture, including change of state and vertical and horizontal transport, of the interchange of water substance between the earth, the atmosphere and the seas.

inversion - refers to temperature inversion; a departure from the usual decrease in temperature with increasing height. Effectively, warmer air capping colder air layers.

low pressure area - an area subject to a minimum of atmospheric pressure in two dimensions on a synoptic weather chart.

macroclimate - the general large-scale climate of a large area or country.

macroclimatic processes - the physical and thermodynamic interaction between climatic controls.

macroclimatic region - a geographical area which is influenced by a common set of macroclimatic processes.

macroclimatic subregion - a distinct portion of a macroclimatic region where the intensity, frequency or peristency of interaction between macroclimatic processes differentiates the climate from that of the rest of the region.

mesoclimate - the climate of a small area of the earth's surface which may not be representative of the general climate of the district.

microclimate - the fine climatic structure of the air space which extends from the very surface of the earth to a height where the effects of the immediate character of the underlying surface no longer can be distinguished from the general local climate.

orographic lifting - the lifting of an air current caused by its passage up and over a mountain barrier.

orographic subsidence - the descending motion of the air in the atmosphere after it has cleared the mountain barrier over which the air was orographically lifted.

persistence - the tendency for the occurrence of a specific event to be more probable, at a given time, if that same event has occurred in the immediately preceding time period.

rainshadow - the region on the lee side a mountain or mountain range, where precipitation is noticeably less than on the windward side.

Rocky Mountain gap - represented by the Hart Ranges of the Rocky Mountains; constitutes a central mountain belt which is of lower elevation than either the Muskwa Ranges to the north or the Continental Ranges to the south.

synoptic surface chart - a comprehensive and nearly instantaneous graphical representation of the state of the atmosphere over a wide area of the earth's surface.

temporal weather continuum - the continual, never-ending, existence and metamorphosis of weather through time.

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ECOLOGICAL LAND CLASSIFICATION BASED WILDLIFE HABITAT EVALUATION IN WEST-CENTRAL ALBERTA: WOODLAND CARIBOU WINTER HABITAT SUITABILITY

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ABSTRACT

A program of integrated resource planning for provincial public lands is carried out by Alberta Forestry, Lands and Wildlife. Ecological Land Classification provides a focus for planning team discussion of resource issues and an information base from which multiple evaluations can be made. Evaluation techniques are being developed in consultation with each resource agency. One wildlife habitat evaluation, woodland caribou winter habitat suitability is presented as an example of the process of methods development. The ways in which this activity supports the objectives of the Department and the Fish and Wildlife Division are outlined.

A computed-assisted model was developed for use at the 1:100 000 scale with Ecological Land Classification from an existing small scale model used by the Fish and Wildlife Division. The model was used to assess winter caribou habitat in west-central Alberta. Recommendations are made for model and data improvements and regarding the use of this approach.

RÉSUMÉ

Un programme de gestion intégrée de ressources pour les terres publiques provinciales est conduit par le Ministère des forêts, des terres et de la faune de l'Alberta. La classification écologique du territoire fournit un point pour la discussion, par l'équipe de planification, des issues de ressources et la base d'information pour de multiples évaluations. On développe les techniques d'évaluation en consultation avec les agences de ressources. On présente ici une évaluation, pour les aptitudes d'habitat pour le caribou, comme un example du processus de développement de méthodes. On décrit les façons dont cette activité complémente les objectifs du ministère et la Division de la pêche et de la faune.

Un modèle qui est automatisé a été développé pour être employé à l'échelle 1:100 000 avec les classifications écologiques du territoire d'après un modèle à l'échelle réduite employé par la Division de la pêche et de la faune. Le modle a été employé pour évaluer l'habitat hivernal de caribou dans l'Alberta ouest-central. On propose des recommendations pour les améliorations de modèles et de données et concernant l'usage de cette approche.

INTRODUCTION AND OBJECTIVES

The purpose of this paper is to outline the development process for woodland caribou winter habitat suitability evaluations within the context of the general planning and management activities of Alberta Forestry, Lands and Wildlife.

The Department conducts a program of integrated resource planning, which is coordinated by the Resource Evaluation and Planning Division (REAP). This planning program for public lands in Alberta functions with the philosophy of shared decision-making and is carried out by teams of resource team representatives. This decision-making process is aided by integrated resource inventories and the use of Ecological Land Classification (ELC) maps. The ELC links resource information and evaluations to one set of map polygons which depicts recognizable, repeating ecological landscapes. This provides a focus for team discussion and is an efficient and cost-effective process by which many resource clients can be served from one information base.

The woodland caribou winter habitat suitability assessment for the Fish and Wildlife

Division (F&W) was selected for discussion in this paper because of the simplicity of the evaluation model. The development of this evaluation technique serves three purposes within the Department.

1) It provides wildlife habitat information for integrated resource planning at the sub-regional level (1:100 000).
2) It is compatible with F&W program of wildlife resource assessment for the Province since similar methods for habitat evaluation are used.
3) It supports the development of a geographic information system which requires computerized data handling.

The model was used to assess caribou winter habitat in the Berland area in west-central Alberta, an area under study in anticipation of sub-regional planning. Several of Alberta's few remaining woodland caribou herds winter in the Berland area (Edmonds and Bloomfield 1984). For this paper a portion of the Berland area within the wintering grounds of two of the caribou herds is used to illustrate the modelling technique.

The sub-area includes the Little Smoky Valley ecodistrict, a wide flat valley with pine/lichen forests on glaciofluvial sands and gravels, and fens in the organic depressions. It is bordered by till-covered uplands: the Simonette Upland with old subalpine forests which support abundant arboreal lichens and some terrestrial lichens where surficial materials are thin; and the Berland Plateau, an area of extensive coniferous forests and fens.

METHODS

The ELC data used for the modelling process and a description of the model developed for the evaluation are outlined in this section. Although they are discussed independently, some of the specifics of the data collection and variables in the model were developed jointly.

Ecological Land Classification and Data Bases

A 1:100 000 scale ELC ecosection map was prepared based on air photo interpretation and field sampling of surficial materials, soils and vegetation. A complete description of inventory methods is documented elsewhere (Alberta. Resource Evaluation and Planning Division 1985). For evaluation purposes a computerized ecosection data base was created which includes a list of landforms, slopes, soils, drainage, and land cover types with relative occurrence of each component, for each ecosection.

A second data base contained all the data describing land cover types. Land cover types are plant associations, and other cover types such as clearcuts, recent burns and water. Plant associations were determined by grouping field sampling sites similar in floristics and environmental conditions. Field data were not collected for the clearcuts, recent burns or water. The data base includes the vegetation parameters relevant to this evaluation: the abundance of terrestrial and arboreal lichens.

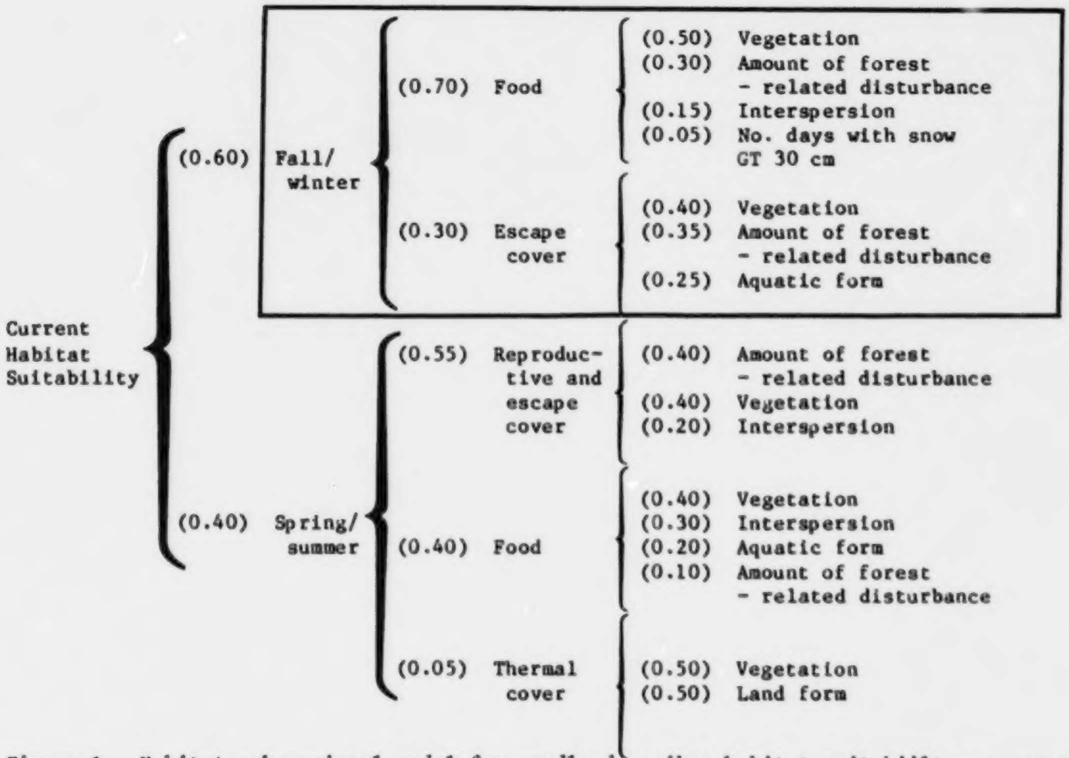
The Model

The computer-assisted modelling of wildlife habitat discussed here was designed to parallel the approach being used by F&W. An overview of F&W's habitat evaluation program is presented by Eng and Stelfox (this volume). As part of the program, species-habitat relationship models were prepared for seven priority wildlife species, including woodland caribou (IEC Beak 1984). The models were designed to apply at the habitat sub-region level (1:1 000 000). The habitat sub-region model for woodland caribou (Figure 1) formed the basis for the development of the 1:100 000 ecosection model (Figure 2). This derived model is limited to winter habitat, as requested by the client.

The variables in the ecosection model and the weightings applied to the variables were determined by a team of experts with knowledge of the region, woodland caribou habitat requirements, the modelling process and the ELC and associated data.

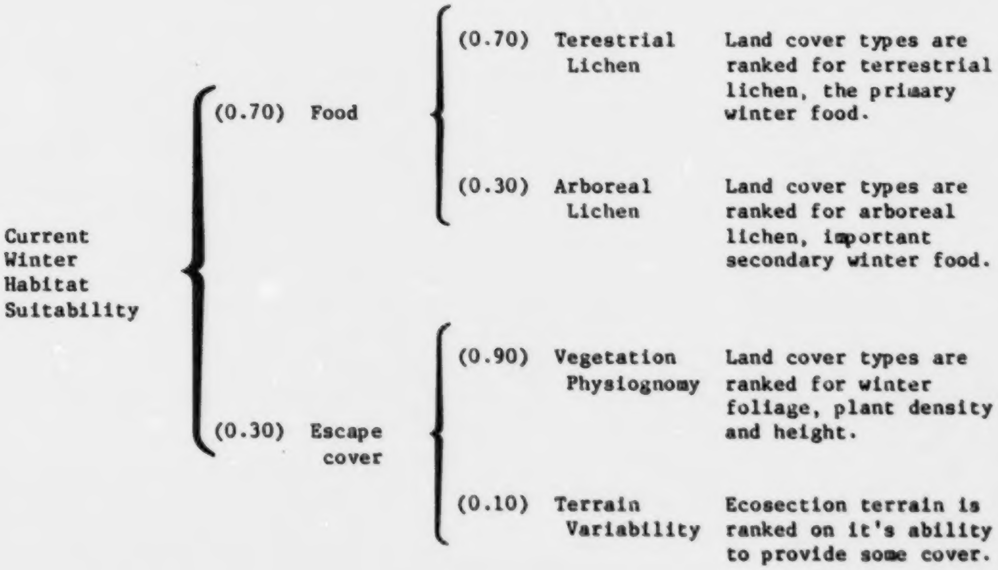
Winter habitat suitability was based on the two life requisites, food and escape cover. Food was determined to be primarily terrestrial lichen, with arboreal lichen being an important secondary food. Escape cover was provided by vegetation and terrain. These variables differ from those in the habitat sub-region model, partly because of the change in scale.

In the habitat sub-region model food was inferred from the physiognomy of the vegetation, with coniferous forests being the best sources of food. In the ecosection model food was assessed more directly from terrestrial and arboreal lichen data collected in the field and averaged for each plant association. Forest disturbance was removed as a separate variable and burns and clearcuts were included in the list of land cover types.



- Current Habitat Suitability
  - (0.60) Fall/winter
    - (0.70) Food
      - (0.50) Vegetation
      - (0.30) Amount of forest - related disturbance
      - (0.15) Interspersion
      - (0.05) No. days with snow GT 30 cm
    - (0.30) Escape cover
      - (0.40) Vegetation
      - (0.35) Amount of forest - related disturbance
      - (0.25) Aquatic form
  - (0.40) Spring/summer
    - (0.55) Reproductive and escape cover
      - (0.40) Amount of forest - related disturbance
      - (0.40) Vegetation
      - (0.20) Interspersion
    - (0.40) Food
      - (0.40) Vegetation
      - (0.30) Interspersion
      - (0.20) Aquatic form
      - (0.10) Amount of forest - related disturbance
    - (0.05) Thermal cover
      - (0.50) Vegetation
      - (0.50) Land form

Figure 1: Habitat sub-regional model for woodland caribou habitat suitabiilty assessment (IEC Beak 1984). The box encloses the portion of the model used to derive the ecosection model.



- Current Winter Habitat Suitability
  - (0.70) Food
    - (0.70) Terestrial Lichen — Land cover types are ranked for terrestrial lichen, the primary winter food.
    - (0.30) Arboreal Lichen — Land cover types are ranked for arboreal lichen, important secondary winter food.
  - (0.30) Escape cover
    - (0.90) Vegetation Physiognomy — Land cover types are ranked for winter foliage, plant density and height.
    - (0.10) Terrain Variability — Ecosection terrain is ranked on it's ability to provide some cover.

Figure 2. Ecosection model for woodland caribou winter habitat suitability assessment.

In the interest of producing the simplest model that would give satisfactory results, two of the variables in the habitat region model were omitted. "Interspersion" and "number of days with snow on the ground greater than 30 cm" were dropped because of the low relative importance of these factors.

Escape cover provided by vegetation was determined similarly in both models. The amount of coniferous vegetation, plant height and stem density were assessed. The aquatic forms of the habitat sub-region model were not treated in the same way for both models, with some aspects of aquatic habitats included in the land cover types and some in terrain variability in the ecosection model. Terrain variability was added to the ecosection model as cover can be provided by the land itself due to local relief.

The ecosection model was designed to identify the best quality habitat and not the most highly used habitat. This is particularly important in relation to caribou, animals which traditionally feed in and travel through particular areas and not others.

Modelling

The variables required for the modelling process were ranked on a scale of 0 (inadequate) to 3 (best). The ranks for the amount of terrestrial and arboreal lichen in each land cover type were determined by two processes. Classes were established for plant associations based on the field data. Other land cover types such as burns, clearcuts and water, were ranked based on the knowledge of inventory specialists. Dry lodgepole pine forests on well drained glaciofluvial deposits had the greatest cover of terrestrial lichen. Old subalpine coniferous forests had the most abundant arboreal lichen.

The escape cover value of the land cover types was determined from the field data for each plant association and from general knowledge for the other types. Dense coniferous forests were best while non-vegetated areas were inadequate. The amount of local variability in the terrain of each ecosection was ranked directly during air photo interpretation.

The woodland caribou winter habitat suitability model was programmed and the ecosection and land cover data bases were entered on the IBM-PC for easy data handling. For each ecosection the computer selected the appropriate attribute from the ecosection data base. If the attribute was a land cover type, the program located the corresponding type in the land cover data base to find the variable ranking assigned to that cover type. Calculations were made based on the weightings in the model. For a description of how the model works and a sample of the calculations see Eng and Stelfox (this volume).

RESULTS AND DISCUSSION

Evaluation Results

To illustrate the results a sub-area of the Berland is presented. An excerpt of the ecosection data base for 20 ecosections is given in Table 1. Part of the land cover data base is listed in Table 2. Table 3 gives preliminary evaluation results for the 20 ecosections. These data are extracted from the report on the Berland study (Alberta. Resource Evaluation and Planning Division in prep.).

The ecosection known to have the best terrestrial lichen is LSV.GF1. Pine/lichen forest covers 70% of its area. But the dry conditions that promote terrestrial lichen growth result in poor arboreal lichen production. Escape cover values are moderate due to openness of the forest and the flatness of the terrain. The end result is a suitability rating of moderate. The good terrestrial lichen is counterbalanced by the poor arboreal lichen.

Ecosection SU.MP1 contains the land cover type with the best arboreal lichen, 6SxFaPl5. This is an old subalpine forest type where time and environmental conditions have resulted in abundant arboreal lichens. But this type covers only 20% of the ecosection and contains no terrestrial lichen. The ecosection has 30% coverage by 6PlFa3. In this type, thin surficial materials have resulted in an open forest with abundant terrestrial lichen, but little arboreal lichen. The value of the escape cover is slightly reduced due to the flatness of terrain and the openness of some of the forest. The habitat suitability rating for the ecosection is moderate. The variability of the ecological conditions in this ecosection result in an overall rating of moderate.

The highest suitability rating was computed for BP.M2. This ecosection is completely forested with types which all have some terrestrial and arboreal lichen and also provide good cover. Overall this ecosection of coniferous forests achieves a moderate

Table 1: Excerpt of ecosection data base for 20 ecosections

Ecosection[a]	T.V.[b]	Land Cover Types (occurrence)[c]											
LSV.GF1	1.5	10P12	(.7)	10SbP16	(.1)	10f7	(.1)	Water	(.1)						
LSV.GF2	1.5	10P12	(.1)	10/6P12	(.1)	10/6P1Sb4	(.2)	10P1Sb4	(.2)	10SbP16	(.2)	10Sb7	(.1)	10f7	(.1)
LSV.F5	1.0	0Sw5	(.8)	0m4	(.1)	0m6	(.1)								
LSV.F6	1.0	0m6	(.4)	0Sw5	(.1)	10f7	(.4)	Water	(.1)						
LSV.F7	2.0	0m4	(.1)	0Sw5	(.8)	10P1Sb4	(.1)								
LSV.F8	2.0	0Sw5	(.4)	10P1Sb4	(.1)	0m4	(.3)	0m6	(.2)						
LSV.GF01	1.0	10P12	(.2)	10P1Sb4	(.1)	10P1Sb6	(.3)	10Sb7	(.3)	10f7	(.3)				
LSV.GFM1	2.0	10/6P1Sb4	(.1)	10P12	(.2)	10P1Sb4	(.1)	10SbP16	(.2)	10Sb7	(.1)	10f7	(.2)	10Cut	(.1)
LSV.GLGF1	1.0	10SbP16	(.4)	10P1Sb4	(.4)	10Sb7	(.1)	0m6	(.1)						
LSV.M1	2.5	5Aw3	(.1)	10P1Sb4	(.4)	10SbP16	(.1)	9/10P1Aw4	(.1)	10f7	(.1)	10Sb7	(.1)	10P12	(.1)
LSV.MGF1	2.0	10/6P1Sb4	(.1)	10/6SbP16	(.1)	10P1Sb4	(.4)	10SbP16	(.1)	10P12	(.2)	10f7	(.1)		
LSV.01	1.0	10f7	(.3)	10f8	(.5)	10Sb7	(.1)	10SbP14	(.1)						
SU.CM3	2.0	10Cut	(.1)	10/6P14	(.3)	6SxFaP15	(.2)	6P14	(.2)	10/6P1Sb4	(.1)	10P1Sb4	(.1)		
SU.MC1	3.0	6Sx5	(.3)	10/6P1Sb4	(.2)	10/6SbP16	(.1)	10/6P14	(.3)	6f7	(.1)				
SU.MP1	1.0	6P14	(.2)	6SxFaP15	(.2)	6P1Fa3	(.3)	10/6P1Sb4	(.2)	10/6SbP16	(.1)				
BP.GF1	1.0	10/6P12	(.3)	10/6SbP16	(.1)	10P12	(.2)	10SbP16	(.1)	6P14	(.1)	0m6	(.1)	10f7	(.1)
BP.GFM1	1.5	10/6P1Sb4	(.2)	10/6SbP16	(.5)	10Sb7	(.2)	10f7	(.1)						
BP.M2	1.0	10/6P1Sb4	(.2)	10/6SbP16	(.3)	10/6P12	(.1)	10P1Sb4	(.3)	10SbP16	(.1)				
BP.MGF1	2.0	10/6P1Sb4	(.3)	10/6SbP16	(.1)	10P1Sb4	(.3)	10SbP16	(.1)	10Sb7	(.1)	10f7	(.1)		
BP.MO2	3.0	10/6P1Sb4	(.3)	10/6SbP16	(.3)	10Sb7	(.2)	10f7	(.2)						

[a] LSV.GF1 - ecosection code

LSF - Little Smoky Valley ecodistrict
GF1 - 1st glaciofluvial ecosection within the ecodistrict

[b] T.V. - Terrain Variability

[c] 10P1Sb4 - land cover type code

10 - Boreal Uplands ecoregion
P1Sb - lodgepole pine-black spruce
4 - mesic moisture regime

rating. There is a range of variable rankings but with no zero values.

For this group of 20 ecosections the lowest suitability rating is for LSV.F6. This is a small river system where meadows and fens cover most of the area. These are cover types which provide little food or cover.

There is no ecosection rated as best in the study area. In view of the ecosections described above this result seems reasonable. At this time the data are ranked only within each study area and are not necessarily applicable to the province as a whole. However, it is interesting to note that the best terrestrial lichen grows in the northeast part of the province, not in this region.

There is local variability in the amount of lichen, but all the ecosections in the Subalpine and Boreal Uplands ecoregions that have predominantly coniferous forests have moderate habitat suitability (the ecoregions of Alberta are described by Strong and Leggat 1981). Ecosections with deciduous forests, non-treed meadows, or fens in all ecoregions, and coniferous forests in other ecoregions have lower ratings. This is the habitat stratification that results from using a four class system of habitat suitability.

Model and Data Requirements

Although it appears that the model is giving reasonable results, changes in data collection and the model may improve the evaluation.

Subjective estimates of arboreal lichen abundance between 0 and 2.5 m were made at all sample sites. Field investigators felt that benchmarks for each of the abundance classes were hard to establish, because of the confusion caused by variable tree density and tree height.

Woodland caribou in this area tend to use open areas because it is easier to detect predators (Edmonds and Bloomfield 1984). Once they determine that escape is necessary they flee into adjacent forest. Cover types are only assessed for food or escape cover and not for predator detection. The model could be refined to include a measure of the interspersion of open and closed forest cover types; or the variable rankings for open cove types could be adjusted to have greater value as escape cover. In the future, geographic information system software could be used for calculating interspersion values.

*Table 2: Land cover types with variables ranked**

Land Cover Types	Terrestrial Lichen	Arboreal Lichen	Escape Cover
5Aw3	0	0.0	1
6P1Fa3	3	1.0	2
6P14	1	2.0	3
6SxFaP15	0	2.5	3
6Sx5	0	1.5	3
10/6P12	3	2.0	3
10/6P1Sb4	2	1.0	3
10/6SbP16	2	1.5	3
10P12	3	1.0	3
10P1Sb4	1	2.0	3
10SbP16	1	1.5	3
10Sb7	1	1.5	2
10Sw5	1	1.0	3
10P14	0	1.5	3
10f7	0	1.0	1
0m4	1	0.0	1
0m6	0	0.0	1
0Sw5	1	2.0	3
10Cut	0	0.0	1
Water	0	0.0	0

* 3 best
2 moderate
1 poor
0 inadequate

Use of the Results

The final ratings provide basic classification of the ecological units for general planning and management purposes. The results seem reasonable for this purpose. The results also provide an appreciation of the nature of caribou habitat in this area. There is a patchwork of different cover types with the highest ratings occurring in the areas of coniferous forest in the Subalpine and Boreal Uplands ecoregions.

Beyond this general view of caribou habitat, more information can be gleaned about the location of areas of high terrestrial or arboreal lichen by looking at the interim variable scores in Table 3. Potentially important ecosections for food and cover can be identified in this way.

An ecosection is a relatively small unit in terms of woodland caribou habitat. Caribou require large tracts of habitat (Nietfeld et al. 1985). Therefore, although particular ecosections may be more valuable than others

Table 3: Preliminary evaluation results for woodland caribou winter habitat suitability

Ecosection	Terrestrial Lichen 1	Arboreal Lichen 2	Vegetation Physiognomy 3	Terrain Variability 4	FOOD 5	COVER 6	CURRENT WINTER HABITAT SUITABILITY 7	8
LSV.GF1	1.54	0.29	2.25	0.15	1.28	0.72	2.00	M
LSV.GF2	1.05	0.44	2.43	0.15	1.04	0.77	1.81	M
LSV.F5	0.63	0.48	2.34	0.10	0.78	0.73	1.51	M
LSV.F6	0.07	0.18	0.99	0.10	0.17	0.33	0.50	I
LSV.F7	0.70	0.54	2.52	0.20	0.87	0.82	1.68	M
LSV.F8	0.56	0.30	1.80	0.20	0.60	0.60	1.20	P
LSV.GF01	0.91	0.48	2.43	0.1	0.97	0.76	1.73	M
LSV.GFM1	0.84	0.35	2.07	0.20	0.83	0.68	1.51	M
LSV.GLGF1	0.63	0.47	2.43	0.10	0.77	0.76	1.53	M
LSV.M1	0.63	0.42	2.25	0.25	0.74	0.75	1.49	P
LSV.MGF1	1.05	0.45	2.52	0.20	1.05	0.82	1.87	M
LSV.01	0.14	0.35	1.17	0.10	0.34	0.38	0.72	I
SU.CM3	0.56	0.45	2.52	0.20	0.71	0.82	1.52	M
SU.MC1	0.63	0.33	2.52	0.30	0.67	0.85	1.52	M
SU.MP1	1.19	0.47	2.43	0.10	1.16	0.76	1.92	M
BP.GF1	1.33	0.42	2.34	0.10	1.23	0.73	1.96	M
BP.GFM1	1.12	0.41	2.34	0.15	1.07	0.75	1.81	M
BP.M2	1.19	0.48	2.70	0.10	1.17	0.84	2.01	M
BP.MGF1	0.91	0.44	2.43	0.20	0.94	0.79	1.73	M
BP.MO2	0.98	0.38	2.16	0.30	0.95	0.74	1.69	M

1. Weighted contribution made to FOOD by terrestrial lichen (maximim of 2.1)
2. Weighted contribution made to FOOD by arboreal lichen (maximum of .9)
3. Weighted contribution made to COVER by vegetation physiognomy (maximum of 2.7)
4. Weighted contribution made to COVER by terrain variability (maximum of .3)
5. Weighted contribution made to SUITABILITY by FOOD (maximum of 2.1)
6. Weighted contribution made to SUITABILITY by COVER (maximum of .9)
7. Result of computations for CURRENT WINTER HABITAT SUITABIITY (maximim of 3)
8. Result converted to CURRENT WINTER HABITAT SUITABILITY CLASSES

M - moderate	(1.5 - 2.25)
P - poor	(.75- 1.5)
I - inadequate	(0 - .75)

for specific habitat variables, blocks of ecosections which together satisfy caribou habitat requirements would be required to maintain a caribou population. This may be a important consideration for planning purposes.

This modelling process will help identify where the best quality caribou habitat is located. However, woodland caribou are animals of habit and traditionally use some areas more than others, despite habitat quality. For some purposes, it may be necessary to consider habitat quality and information on caribou use together.

An important final point is that these data and results are intended for planning and management decisions at 1:100 000 scale. For site specific or operational decisions, field inspection is required to establish the conditions at a particular point.

CONCLUSIONS AND RECOMMENDATIONS

Basically, the model is good for the purpose for which it was designed and can provide the level of information required for sub-regional planning.

A few changes in data collection and in the model itself may improve the results.

The model would have general applicability where terrestrial and arboreal lichen are the main food items, where escape cover is important and provided mainly by vegetation, and where a similar level of field data are available to support the analysis. However, the simplicity of the pattern of the results suggests that a more general level of data, that is ecoregion and physiognomy of the vegetation, may be adequate to produce similar results. Further study would be required to confirm or refute this hypothesis.

This computer-assisted evaluation of wildlife habitat will provide information directly to F&W for their program of wildlife resource assessment and will allow the Department to effectively conduct wildlife habitat evaluations within a geographic information system.

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WILDLIFE HABITAT DISTRICT MAPPING — ROCKY MOUNTAIN HOUSE (83B) ALBERTA

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INTRODUCTION

An Alberta Wildlife Habitat Inventory is underway to generate information suitable for wildlife planning and management purposes. Over the next few years there will be development of both graphic and attribute data bases which can offer appropriate mechanisms for the determination of current status and the projection of trends under various habitat assumptions. A provincial map at a scale of 1:1,000,000 has been completed. These project elements require the mapping and evaluation of current status, changing trends and the development potential of the habitat land base across a broad spectrum of habitat related ecological phenomena. The resulting map and attribute data are to be digitally encoded for computer storage, manipulation/modelling, and maintenance.

This paper focuses on the procedures used in the mapping of wildlife habitat districts in the first 1:250,000 scale project (Leskiw et al., 1984). Linear surface disturbances and areal surface disturbances, were also mapped but these are not discussed in this paper. The mapping systems were developed primarily for interpretation and synthesis of existing land-related information, including aerial photography and Landsat imagery. A minimal amount of field checking was conducted.

STUDY AREA

The Rocky Mountain House Sheet (83B) was chosen as it is characterized by a diversity of landscapes, land uses and wildlife species. Also, there was considerable relevant published information covering the area. An hierarchical breakdown of the area indicates that there are 6 Regions, 19 Subregions and 258 Districts. Table 1 indicates the selected important wildlife species represented.

Table 1. Wildlife Species Priorities/Habitat Region Matrix for 83B.

WILDLIFE SPECIES IMPORTANCE IN 83B	HABITAT REGIONS IN 83B				
	Aspen Parkland	Boreal Mixedwoods	Boreal Foothills	Boreal Uplands	Alpine/ Subalpine
Primary Consideration					
moose		x	x	x	x
mule deer	x	x	x	x	x
white-tailed deer	x	x	x	x	
elk		x	x	x	x
beaver	x	x	x	x	
sharp-tailed grouse	x	x	x		
breeding dabbler ducks	x	x	x		
ring-necked pheasant	x				
Secondary Consideration					
mountain goat					x
bighorn sheep					x
grizzly bear			x	x	x
marten		x	x	x	x
river otter			x	x	
breeding Canada geese	x	x			
staging & migrant waterfowl	x	x	x		

WILDLIFE HABITAT DISTRICT MAPPING SYSTEM

The WHD mapping was accomplished by a team of soil scientists and wildlife biologists working together to interprete and integrate existing specialized information. Important data sources included ecological land classification, soil survey, access maps, national topographic series maps, aerial photography, Landsat imagery, references pertaining to wildlife in the region and, of course, information compiled by the Habitat Region mapping of the Province at a scale of 1:1,000,000.

Legend components selected for use in the wildlife habitat district mapping and their relationship to the provincial mapping are summarized in Figure 1.

Figure 1. Outline of Wildlife Habitat Mapping Levels and Components Recognized at Different Scales.

Hierarchical Framework

Wildife Habitat Region
12 Regions in the Province (6 in Map Sheet 83B)
⇩
Wildlife Habitat Subregion
278 Subregions in the Province (19 in Map Sheet 83B)
⇩
Wildife Habitat District
258 Districts in Map Sheet 83B
(Target 100 to 200 per map sheet in future surveys)

Mapping Level	Legend Components
1:1,000,000	
Region	lithology, geological structure, climatic vegetation - soil patterns.
Subregion	current vegetation cover, landforms, relief aquatic forms, soils (Orders, Great Groups or Subgroups), ecological moisture regimes and land surface disturbance.
1:250,000	
Region	same as above.
Subregion	same as above with minor modifications to suit cartographic detail.
District	Diagnostic Features: landforms, relief, aquatic forms (areal and linear forms, density and permanency), current vegetation cover, interspersion. Supplemental Attributes: areal and linear surface disturbances, soils (Orders, Great Groups or Subgroups) soil surface type, soil reaction, soil texture, soil moisture regime, drainage class, and root zone available water holding capacity.

Definitions for key terms as used in the habitat mapping are:

Wildlife Habitat District - a land area characterized by a distinct assemblage of landforms, aquatic forms, vegetation, soils and moisture regime, that are considered to be important for a variety of selected wildlife species;

Diagnostic features - those features which are used to distinguish (delineate and define) map polygons;

Supplemental Attributes - those features which provide additional habitat district data which are also useful for interpreting habitat quality and habitat utilization for a variety of wildlife species.

Identification of Diagnostic Features

Wildlife input to the preparation of the Wildlife Habitat District Map focused on the identification of key features which are among many habitat attributes commonly described in land resource surveys.

The following were considered in devising diagnostic features:

- each habitat region has a different wildlife species complex considered important for management purposes;
- the relative importance of landscape attributes in meeting the life requisites of the selected complex of species; and
- diagnostic features selected should lend themselves to efficient and objective handling.

Wildlife species priorities, as presented in Table 1, for WHD mapping and evaluation were based on the following key factors:

- relative importance of the species within a provincial and regional wildlife management context - this is closely correlated with public demand;
- relative degree to which the species functions as an indicator of habitat features significant to a variety of other wildlife species within the map area; and
- the relative ease and usefulness of assessing a wildlife species' habitat conditions as a basis for evaluating current and potential population levels.

The wildlife species-habitat relationship models prepared by I.E.C. Beak (1984) for use at a 1:1,000,000 scale, provided the framework to help rank the habitat attributes recognizable at a 1:250,000 scale.

The key points of the above models were that several different life requisites (e.g. food, water, escape cover, reproductive cover) were established for all species and the various habitat attributes were ranked, based on literature interpretations, from inadequate to best in terms of how well they fulfilled each life requisite for each species. These rankings were identified as "variable rankings" by I.E.C. Beak. I.E.C. Beak provided a further relative ranking for how important a particular life requisite was in a species survival during a particular season, to develop a current habitat suitability rating.

In ranking habitat attributes at 1:250,000, a relative "importance value" was determined of different features (e.g. types of landform) for meeting each species' life requisites. This ranking was determined by transforming the categories of variable ranking for each life requisite of a species, into a numerical importance value. Where I.E.C. Beak identified a variable as inadequate, poor, moderate or best, the importance values of 0, 1, 3 or 5, respectively, were arbitrarily assigned.

For several species in the species-habitat relationship models, a variable had different rankings for different life requisites. The value calculated for 1:250,000 scale use, was the average of all such rankings after they had been transformed numerically. For example, bighorn sheep require certain landform features to provide suitable habitat. The ranking for a "Recent Valley" landform category was best, poor and best, respectively, for the life requisites thermal cover, reproductive cover, and escape cover, based on the species-habitat relationship model. Using the numerical transformation, the respective importance values are 5, 1 and 5 and the overall average is 3.7.

The importance values for habitat attributes were tabulated for the individual species within habitat regions and then an overall average value was calculated from all the species' values. A "relative importance code" was developed to group importance values as follows:

(A) Most Suitable - value of 3.5 or greater for the average of all species
(B) Moderately Suitable - Special Value - average value less than 3.5 but with a value of 5 for one or more species
(C) Moderately Suitable - value 1.5-3.5 for the average of all species
(D) Least Suitable - value of 0-1.4 for the average of all species.

Table 2 shows the numerical ranking for key habitat attributes, i.e. diagnostic features as shown in the extended legend, for individual species and species complexes within one habitat region. Table 3 shows the relative importance code for these diagnostic features.

The function of the relative importance code is to help mappers to interpret existing maps, regarding when to separate units and when to combine map units featuring different habitat attributes, in a manner that reflects the significance of the habitat attribute to wildlife.

Habitat attributes with a code of Most Suitable or Moderately Suitable - Special Value are very important to wildlife and all types should be separated wherever size of unit allows. Similarly, Least Suitable habitat attributes will exclude wildlife and their separation as distinct map units is important also. Those habitat attributes that are designated Moderately Suitable are of lesser importance for distinguishing map units. The identification of Most and Least Suitable habitat attributes provides a very useful perspective for management activities targeted towards a particular complex of wildlife species. As a special case in the above approach to dealing with habitat attributes of differing relative importance, the Moderately Suitable - Special Value code ensures that where a single species has an extremely important habitat attribute requirement, in contrast to the majority of the species complex, it is not ignored.

Importance values and relative importance codes were also determined for the modifiers for the various habitat attributes including: wetland density, wetland permanence, and relief (Leskiw, et al., 1984).

Identification of Supplemental Attributes

The three main types of supplemental data considered relate to land surface disturbance, soils, and moisture regime. Land surface disturbance provides an indication of both areal and linear disturbances, in other words, human influence on the natural environment. Soils includes soil subgroup, soil surface type (presence or absence of organic matter and type), and soil reaction which provide an indication of soil fertility and chemical properties, as well as problems such as acidity, salinity and sodicity. Soil texture, combined with knowledge of soil subgroup and soil surface type, provides important insight into soil physical properties including tilth, permeability, and structure. Moisture regime is described by moisture regime subclass (i.e. degree and duration of saturation in well drained soils as governed by climate), soil drainage class, and available water holding capacity in the root zone.

An important item that is not directly included in the WHD mapping at this time is a direct biological interpretation of climate (snowfall depth and duration, temperature, rainfall, etc.)

Mapping Steps

The specific mapping steps that were followed and hence, the guidelines for mapping are:

- Highlight map unit boundaries based on landform and relief using the relative importance code to determine which map units to separate, i.e. separate (A) Most Suitable, (B) Moderately Suitable - Special Value, (C) Moderately Suitable and (D) Least Suitable land areas at a high level of resolution. Distinguish map units within one category at a lower level of resolution.

Table 2. Importance Values[1] for Selected Diagnostic Features for the Boreal Foothills Region, Rocky Mountain House Sheet.

LANDFORMS

	B^2	BG	BL	BQ	BS	C	E	F	G	L	FL	MG	MH	MR	M/B	M/X	X	I	O	VG	VR
Average	0	0	0.1	0	0.3	0	4.1	3	2.9	1.9	2	3.4	5	4.1	3.1	1.4	1.6	-	1.6	4.6	4.4
Moose	0	0	0	0	0	0	5	3	3	1	1	3	5	5	3	3	3	-	1	5	5
Mule Deer	0	0	0	0	0	0	5	3	3	1	1	3	5	5	5	1	1	-	1	5	5
White-tailed Deer	0	0	0	0	0	0	5	3	3	1	1	3	5	5	5	1	1	-	1	5	5
Elk	0	0	0	0	0	0	5	3	3	1	1	3	5	5	5	1	1	-	1	5	5
Beaver	0	0	1	0	1	0	3	3	3	3	4	3	5	3	1	1	1	-	1	5	4
Sharp-tailed Grouse	0	0	0	0	1	0	5	3	2	3	3	4	5	3	2	2	3	-	3	4	4
Breeding Dabblers	0	0	0	0	0	0	1	3	3	3	3	5	5	3	1	1	1	-	3	3	3

AQUATIC FORMS

	R^2	RU	SL	SU	SI	SM	OL	OP	OM	WM	WQ	WQB	WQF
Average	3.7	2.6	3.4	3	3.9	0.4	3.5	4.9	0.4	3.6	1.9	1.9	4
Moose	5	3	3	3	3	0	5	5	0	3	3	3	5
Mule Deer	3	5	3	5	5	0	3	5	0	3	1	1	3
White-tailed Deer	3	5	3	5	5	0	3	5	0	3	1	1	3
Elk	3	1	3	3	5	0	3	5	0	5	1	1	5
Beaver	5	2	5	3	2	1	5	4	1	1	1	1	2
Sharp-tailed Grouse	3	1	3	1	5	1	3	5	1	5	5	5	5
Breeding Dabblers	3.7	1	3.7	1	2.3	1	2.3	5	1	5	1	1	5

VEGETATION COVER

	AE^2	HM	HM/S	S	S/HM	FD	FC	FMD	FMC	PD	GD	M	C	CH	CA	CI	CP	NM	NN	NA
Average	1.8	2.2	3.0	4.2	3.8	4	2.3	3.5	2.4	3.8	3.3	2.8	1.5	2.4	1.5	-	1.6	0.4	0	0
Moose	1.25	0	2	3.5	3	4	3	4	3	2.5	1	2	0	0	0	-	0	0	0	0
Mule Deer	1.5	3	3.5	4.5	4	4	3	4	3	4	4	2.5	2	3	2	-	2	0	0	0
White-tailed Deer	1.5	3	3.5	5	5	4.5	3	4.5	3	5	5	2.5	2.5	5	2.5	-	2.5	0	0	0
Elk	1.8	4	4	3	3	4.2	3.4	3.8	3.4	3	3	2.2	0.6	2	0.6	-	1	0	0	0
Beaver	0	0	1	5	3	5	0.5	3	1	5	3	1	0	0	0	-	0	0	0	0
Sharp-tailed Grouse	1.7	3.3	5	4.7	5	3.7	2.3	3	2.3	5	5	5	2.3	3	2.3	-	2.7	0	0	0
Breeding Dabblers	5	2.3	2.3	3.7	3.7	2.3	1	2.3	1	2.3	2.3	4.3	3	4	3	-	3	3	0	0

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[1] Importance Values:

0 - Inadequate	1 - Poor
3 - Moderate	5 - Best

[2] See Footnotes in Table 3 for definitions.

Table 3. Relative Importance[1] Codes for all Diagnostic Landscape Features Mappable at the Habitat District Level for all Primary Wildlife Species in the Boreal Foothills Region.

LANDFORMS																					
B[2]	BG	BL	BQ	BS	C	E	F	G	L	FL	MG	MH	MR	M/B	M/X	X	I	O	VG	VR
D	D	D	D	D	D	A	C	C	C	C	B	A	A	B	D	C	-	C	A	A

AQUATIC FORMS												
RL[3]	RU	SL	SU	SI	SM	OL	OP	OM	WM	WQ	WQB	WQF
A	B	B	B	A	D	A	A	D	A	B	B	A

CURRENT VEGETATION COVER TYPES																				
AE[4]	HM	HM/S	S	S/HM	FD	FC	FMD	FMC	PD	GD	M	C	CH	CA	CI	CP	NW	NM	NA
B	C	B	A	A	A	C	A	C	A	B	B	C	B	C	-	C	D	D	D

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[1] Relative Importance Code:

Most Suitable	A	(value of 3.5 or greater for combination of species)
Moderately Suitable - Special Value	B	(value less than 3.5 but 5 for one or more species)
Moderately Suitable	C	(value 1.5-3.4 for combined species)
Least Suitable	D	(combined value of 0 to 1.4)

[2] LANDFORM CLASSES

B - Bedrock (undifferentiated) (this category is used to represent all bedrock types)
BG - Bedrock - mostly granitic and plutonic rocks
BL - Bedrock - mostly limestone and dolomite
BQ - Bedrock - mostly quartzite and sandstone
BS - Bedrock - mostly shale, sandstone, siltstone (bedrock types can be complexed: e.g. BS-L indicates both shales and limestone are present)
C - Colluvial
E - Eolian
F - Fluvial (and F-E, fluvial-eolian)
FL - Fluvial-lacustrine
G - Glaciofluvial
I - Icefield
L - Lacustrine
MG - Ground Moraine
MH - Hummocky Moraine
MR - Ridged Moraine
M/B - Morainal veneer over bedrock
M/X - Morainal veneer over residual
O - Organic
VG - Glaciofluvial valley
VR - Recent valley
X - Residual

[3] AQUATIC FORMS

OL - Lakes
OM - Manmade lakes
OP - Ponds
RL - Lower perennial rivers
RU - Upper perennial rivers
SI - Intermittent streams
SL - Lower perennial streams
SM - Manmade streams
SU - Upper perennial streams
WM - Mineral wetlands
WQ - Organic wetlands (bogs & fens)
WQB - Organic wetlands (bogs)
WQF - Organic wetlands (fens)

[4] CURRENT VEGETATION COVER CLASSES

Aquatic

AE - Emergent aquatics

Herbaceous

HM - Mixed grass/forb cover
HM/S - Mixed grass/forb with shrubs subdominant

Shrubland

S - Shrubland
S/HM - Shrubland with subdominant grass/forb

Groveland

GD - Deciduous dominated groveland

Parkland

PD - Deciduous dominated parkland

Forest

FC - Coniferous forest
FD - Deciduous forest
FMC - Coniferous dominated mixed forest
FMD - Deciduous dominated mixed forest

Muskeg

M - Complex vegetation types (bogs and fens usually on Organic soils)

Cultivated

C - Cultivated (annual or perennial forage)
CH - Cultivated - extensive hedges and shelter belts
CA - Cultivated - annual crops
CI - Cultivated and irrigated
CP - Cultivated - perennial forage

Nonvegetated

NW - Nonvegetated water
NM - Nonvegetated mineral
NA - Nonvegetated anthropogenic

- Subdivide the above based on differences in vegetative cover also using the relative importance code to determine whether to separate or combine vegetation types.

- Assign tentative numeric symbols. To help in understanding the map, these sequences are suggested:
  - proceed from extreme to low relief areas,
  - begin with moraine; then proceed from coarse to fine textured materials of other origins; then organic areas; next, stream valleys; and finally, lakes,
  - within the above, generally proceed from drier to wetter areas,
  - within river systems, begin with main channel then proceed from upper to lower elevation tributaries.

- Measure areas of map units.

- Complete the extended legend as shown in Table 4 and finalize the symbols. The following information sources were used in this study:
  - Landforms - Ecological Land Classification and Soil Survey.
  - Aquatic Forms - 1:50,000 scale NTS sheets and 1:60,000 scale black and white aerial photographs.
  - Vegetation - Cover was first mapped from ELC sources but this proved to be inadequate following field inspection, subsequently, mapping was based on interpretation of Landsat imagery, aided by literature information.
  - Interspersion - measured on 1:60,000 scale black and white aerial photographs (1982). Interspersion was determined using a modification of procedures outlined for the provincial scale (Young, 1984).
  - Land Surface Disturbance (LSD) - WHD polygons were superimposed on the two LSD maps and dominant classes of disturbance were noted. Complexes indicate that occurrence of two or three degrees of disturbance as shown separately on the LSD maps.
  - Soils - Subgroups, Texture: from Soil Survey or ELC. Soil Surface Type, Reaction: inferred from knowledge of soil, parent material, vegetation relationships.
  - Moisture Regime - Subclass: from the map of "Soil Climates of Canada". Soil Drainage: from Soil Survey or ELC.
  - Root Zone Available Water Holding Capacity (AWHC) - inferred from knowledge of soil depth and texture.

- Conventions to use in completing the extended legend (Table 4).
  - Each map polygon representing upland areas is assigned a separate symbol.
  - "Numerators" and "denominators" reflect landform - vegetation - soil relationships where appropriate.
  - Superscripts reflect proportions of complexed features to the nearest 10% where known with a reasonable degree of confidence, that is, quantitifed in the original reference. Up to three components are recognzied, the minimum being 10% coverage of an area. (e.g. MG^6 F^3 L^1 indicates 60% ground moraine, 30% fluvial, and 10% lacustrine deposits).

- Prepare an abbreviated legend to accompany the WHD Map. Indicate significant (generally greater than 20 percent occurrence) landforms, relief and vegetative cover.

Mapping Costs

The contract amount for this study was approximately $21,000, or about $3.60 per square mile. This included literature review, mapping approaches, preparing three maps, and final report production. This budget was tight but for future routine work it should be adequate for a similar type of product.

Concerns About The Mapping System

The numerical ranking of habitat requirements for each species and groups of species worked well for "communication" between the wildlife biologist and the pedologist, however, the system developed is rather involved and it is difficult to follow for the reader who might not be thoroughly familiar with it. Therefore, some streamlining is desirable.

Table 4. Extended Legend Categories.

SYMBOL	DIAGNOSTIC FEATURES									SUPPLEMENTAL ATTRIBUTES								
	LANDFORMS		AQUATIC FORMS					VEGETATION		LAND SURFACE DISTURBANCE		SOILS				MOISTURE REGIME		
			Areal Features			Linear Features												
HABITAT DISTRICT (km^2)	Classes	Relief	Form	(Size) Density	Permanency	Form	Density	Current Cover	Interspersion	Areal Disturbances	Linear Disturbances (Access)	Soil Subgroups	Soil Surface Type	Soil Reaction	Soil Texture	Moisture Regime Subclass	Soil Drainage	Root Zone AWHC

In Map Sheet 83B, it was initially planned to give each map polygon a new symbol. This resulted in the creation of too many units so some "short cuts" were taken; namely, assigned all organic units (bogs/fens) the same symbol within a Wildlife Habitat Sub-region, and gave similar streams the same symbol if they occurred within a Sub-region and between two major rivers (Regions). While this approach worked, it seems too confusing for future use.

Within map units, a component (landform, vegetation type) was recognized if it covered 10 percent or more of that unit. This lead to considerable complexity and it probably has little effect on the final evaluation through modeling because of the overall sensitivity of the process. Therefore, it is suggested that 20% of a unit be the minimum.

The extended legend diagnostic attribute categories were workable and generally satisfactory, however, additional data may be helpful under landforms (specifically, surface expression) and under vegetative cover (information about the understory). The aquatic forms also require considerable refinement. It would also be desirable to know something about the wetlands in terms of their internal habitat attributes as well as their relationship to the uplands rather than simply characterizing them on the basis of density and size.

Interspersion was determined by a simple technique using 1:60,000 black and white aerial photographs. In further simplifying map units it seems that more importance could be placed on interspersion.

The extended legend supplemental attributes generally require changes: the surface and linear disturbance categories are suitable but the soils components could be simplified, perhaps related to productivity of forage, shrubs, trees and to rate of advancement of successional stages. Development of a productivity index based on nutrient and moisture regimes may be more appropriate.

Despite the identification of a relative importance code to deal with a single species (i.e. the Moderately Suitable - Special Value), the selection of the species complex to be associated with each habitat region influences the final outcome of the ranking procedure considerably. Therefore, a standardized approach should be established for making the decision regarding inclusion of priority management species in habitat regions for subsequent map sheets.

SUMMARY

Literature, mainly ecological land classification and soil survey, was reviewed and maps were interpreted to prepare a WHD map. Map units were delineated and described in a form similar to ecological land classification but with major emphasis on wildlife requirements.

The mapping approach is hierarchical. Twelve wildife habitat regions are recognized province-wide, which more or less correspond to ecoregions, and these were previously mapped and subdivided into subregions at a scale of 1:1,000,000. This WHD mapping represented the next stage - dividing subregions into districts. A total of 258 wildlife habitat districts are defined in Map Sheet 83B.

A critical part of the study involved selection of physical and biological features of the landscape, referred to as habitat attributes, that are considered to be important to individual wildlife species and to groups of species in a specified region. The most important habitat attributes are called diagnostic features and are assigned numeric values, called importance values. These importance values reflect the significance of the features from a wildlife perspective and therefore serve as guidelines to determining where map unit boundaries should be drawn and they provide the quantitative inputs to modeling studies. Other features that provide very useful information about the environment for wildlife purposes are described for each map unit and these are called supplemental attributes.

In general, the mapping approach provides an objective framework to deal with a clearly subjective assessment. However, the mapping procedures and final map are rather complex hence suggestions for simplifying the approach are given.

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A PROTOTYPE ASSESSMENT OF WILDLIFE RESOURCE STATUS OF THE ROCKY MOUNTAIN HOUSE (83B) NTS MAP SHEET USING AN ECOLOGICAL LAND CLASSIFICATION APPROACH

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ABSTRACT

The Alberta Fish and Wildlife Division is conducting prototype studies for a reconnaissance assessment of wildlife resource status throughout the province of Alberta. The objective is to provide information on wildlife habitat and population status which can be used in provincial and regional wildlife management activities. Status assessments are conducted within the framework of ecological land classification (ELC) maps which depict Wildlife Habitat Districts at a scale of 1:250,000.

Two methods of evaluating habitat quality were investigated for the first prototype map sheet; computerized species-habitat relationship models and subjective manual assessments. An attempt was made to predict potential population (carrying capacity) levels on the basis of the habitat quality evaluations. In addition, information on actual population status was obtained using three methods: summarization of historical population survey data within the ELC map context, ungulate and waterfowl aerial surveys, and ungulate pellet group counts.

This paper summarizes the first prototype assessment of wildlife resource status which was conducted for seven wildife species (or species groups) on the Rocky Mountain House (83B) NTS map sheet area. These initial results indicate a potential to meet the project objectives, however substantial refinement of the methods will be required before the overall results will be acceptable.

INTRODUCTION AND OBJECTIVES

In 1984 the Fish and Wildlife Division of Alberta Energy and Natural Resources initiated an assessment of wildlife habitat and population status in Alberta. The assessment is being conducted for 18 priority wildlife species (groups) including selected big game species, furbearers, upland game birds and waterfowl. The primary reasons for conducting the provincial assessment are:

1. To enable the Fish and Wildlife Division to periodically make a public statement about the status of the province's wildlife resource.
2. To facilitate wildlife species management and habitat management planning at provincial and regional levels, including the establishment of priorities and manpower/budget allocations.
3. To facilitate the input of wildlife resource information into the Alberta Energy and Natural Resources integrated resource planning and management activities.

The process began with the preparation of a Preliminary Wildlife Habitat Regions/Subregions of Alberta map prepared at a scale of 1:1,000,000 (Pedocan Land Evaluation 1984). This map, and its associated legend, delineated and described ecological landscape units which were subsequently evaluated in terms of habitat quality and species distribution for the 18 priority wildlife species (IEC Beak Consultants Ltd. 1984).

Upon completion of the provincial overview a Wildlife Habitat District Map of the Rocky Mountain House (83B) NTS Map Sheet was prepared at a scale of 1:250,000 (Pedology Consultants and McCourt Management 1984). This map, and its associated legend, was based on the

Preliminary Wildlife Habitat Regions/Subregions of Alberta map and it depicts another more detailed level in the ecological land classification - wildlife habitat districts. The extended legend for the map describes each wildlife habitat district in terms of landforms, topography (relief), current vegetation cover and aquatic forms. Each of these biophysical variables is broken down into fixed classification categories which identify, in a general way, the full range of conditions that could potentially occur. In the legend description, a wildlife habitat district can contain up to four categories of some variables with modifiers used to describe the percent coverage of each category. In addition, numerical indices of interspersion of vegetation cover types and certain climatic variables were developed for each district.

The wildlife habitat district map was used as a basis from which to conduct a systematic assessment of wildlife resource status. The objectives of the assessment phase for the Rocky Mountain House (83B) Wildlife Habitat District Map were to develop and implement methodologies which would allow the determination of:

1. Current habitat suitability using a four class scale (best, moderate, poor and inadequate habitat quality in a provincial perspective) for each wildlife habitat district using a computer-aided, species-habitat relationship modelling approach and a more subjective manual assessment approach.

2. The expected population density (carrying capacity) for each class of current habitat suitability.

3. The actual population density for those wildlife habitat districts which had good, recent (less than 6 years old) population data.

These objectives were to be met for each of seven priority species (species group) which occur in the map sheet area; moose, white-tailed deer, mule deer, elk, bighorn sheep, American marten and breeding dabbler ducks.

STUDY AREA

The study area for this project was, in effect, the entire province of Alberta because the methods developed were to be applicable throughout the province. However, the methods were to be tested on the Rocky Mountain House (83B) NTS Map Sheet [52°-53° N. Lat.; 114°-116° W. Long]. The Rocky Mountain House (83B) Map Sheet was chosen for the prototype phase of the project because it exhibits a high degree of ecological diversity which would "test" the provincial applicability of the methods developed. Within the map sheet six habitat regions (climatic Ecoregions) are present; Aspen Parkland, Boreal Mixedwood, Boreal Foothills, Boreal Uplands, Subalpine and Alpine. Land use activities are predominantly agricultural in the eastern portion of the map sheet and forest-related timber harvesting and outdoor recreation in the western portion. Oil and gas exploration and development occurs with varying intensities throughout much of the map area. A few areas in the southwest corner of the map sheet remain relatively undisturbed.

METHODS

Assessment of Current Habitat Suitability

Current habitat suitability is defined as the current ability of an area, e.g., wildlife habitat district map unit, to provide necessary life requisites (food, thermal cover, escape cover, etc.) for a given species. It is rated using a four-class scale (1 = best, 2 = moderate, 3 = poor, 4 = inadequate). Two independent assessment methods were developed and employed; species-habitat relationship models and subjective expert opinion.

1. **Computer-aided assessment using species-habitat relationship models** - For each of the seven priority species a separate species-habitat relationship model was developed based upon existing knowledge of the species key habitat requirements as summarized in Nietfeld et al (1985). An example of the basic model structure, for moose, is presented in Figure 1. A dendogram (tree diagram) was developed with current habitat suitability as the "root" of the tree. Those seasonal habitats which contribute to current habitat suitability are represented by the first "branches" of the tree. Each seasonal habitat is, in turn, composed of the life requisites which a species needs for that seasonal habitat.

Finally, the biophysical variables which contribute to, or detract from, the ability of a land unit to provide a given life requisite are identified. For each

MODEL DENDOGRAM FOR MOOSE

Current Habitat Suitability Node 1	Seasonal Habitat Node 2	Life Requisites Node 3	Aggregation Weighting Values	Variables Node 4	Example Variable Scores (0-3)
Current Habitat Suitability	(0.60) Fall/Winter	(0.55) Food	(0.55)	Vegetation	
			(0.20)	Interspersion	
			(0.10)	Aquatic form	
			(0.10)	Landform	
			(0.05)	No. days with snow > 30 cm	
		(0.35) Thermal cover	(0.55)	Winter severity	3
			(0.30)	Vegetation	0.7
			(0.15)	Relief class	2.8
		(0.10) Escape cover	(0.50)	Vegetation	
			(0.30)	Interspersion	
			(0.20)	Relief class	
	(0.40) Spring/Summer	(0.60) Food	(0.60)	Vegetation	
			(0.20)	Interspersion	
			(0.10)	Aquatic form	
			(0.10)	Landform	
		(0.40) Thermal, reproductive, and escape cover	(0.45)	Vegetation	
			(0.35)	Interspersion	
			(0.20)	Relief class	

EXAMPLE OF CALCULATED VARIABLE SCORES

Calculation of Variable Scores		Biophysical Data For Wildlife Habitat District #8.68.06		Variable Rankings For Thermal Cover During Fall/Winter		
		Winter Severity				
3	←	24.45	←	Best (3)	←	0-44
				Moderate (2)		45-51
				Poor(1)		52-100
		Current Vegetation Cover				
				Best (3)		FC, FMC
0.6 = (30% of 2)	←	FMD (30% cover)	←	Moderate(2)	←	FD, FMD, MT, WC, WM
0.1 = (10% of 1)	←	MM (10% cover)	←	Poor(1)	←	GM, MM, PD, S, S/HM, WD
0.0 = (60% of 0)	←	CP (60% cover)	←	Inadequate(0)	←	AE, C, CA, CP, HM, HM/S, MS, NA, NM, NW
0.7						
		Relief Class				
2.7 = 90% of 3	←	M - 90% cover	←	Best(3)	←	H, M
				Moderate(2)		none
0.1 = 10% of 1	←	L - 10% cover	←	Poor(1)	←	E, L
2.8						

Figure 1. Moose model dendogram (above) and an example of the calculated variable scores (below). Aggregation weighting values on the dendogram are shown in brackets. A current habitat suitability ranking for a particular wildlife habitat district results from inputting a variable score (0-3) for each variable at Node 4 and then calculating weighted averages in a stepwise fashion from Node 4 through Node 1.

identified variable the ability of each category of that variable to provide the identified life requisite is ranked using the four-class system. The current habitat suitability of a wildlife habitat district is determined by calculating scores for each variable based on the ranks assigned to the categories of the variable that are present and on the relative aerial coverage of each category. The variable scores are then aggregated into a single current habitat suitability value in a step-wise fashion by producing weighted averages at each node in the tree. Weighted aggregation values are based on the relative importance each variable, life requisite and season to the survival of the species. This process results in a rating which is essentially subjective because the rankings of individual variable categories and the aggregation weighting values are subjective in nature. However, this method has the advantage that the results are repeatable and the assumptions are well documented. The process of calculating current habitat suitability values using the species-habitat relationship models was mechanized using an IBM-PC computer and a series of computer programs written in BASICA.

2. **Subjective manual assessment of current habitat suitability** - A subjective manual assessment of current habitat suitability was completed for six species using the expert opinion of regional wildlife biologists from the Fish and Wildlife Division (AENR). They rated the current habitat suitability of each wildlife habitat district for each species by relying on their personal knowledge of the area and the species-habitat requirements. Where the biologists were unfamiliar with a particular wildlife habitat district they consulted the biophysical legend information to guide them in their assessment.

Determination of Expected Population Densities

An attempt was made to determine an average expected population density (carrying capacity) estimate and range of densities for each current habitat suitability class and for each priority species. The estimates were derived by species experts who were provided with a review and analysis of existing population data for the area and with the results of the population surveys conducted for this study. If observed average densities were felt to be significantly below the habitat carrying capacity for a given class of current habitat suitability due to past hunting pressure or other non-habitat factors then the expected densities were arbitrarily increased accordingly.

Estimate of Actual Population Densities

Existing, recent (less than 6 years old) population data was summarized within the context of the wildlife habitat district map, where possible. In addition, three field programs were conducted to estimate population densities for selected species in the map sheet area:

1. Winter ungulate aerial surveys - 285 km^2 of total count block surveys conducted from a Bell 206B helicopter.

2. Spring pellet group counts - a total of 445 km of belt transects in 89 of 257 wildlife habitat district.

3. Breeding dabbler duck surveys- 285 km of fixed-wing transect surveys.

RESULTS AND DISCUSSION

The results of the study were presented in the form of wildlife habitat district evaluation legends showing the manual and modelled assessments of current habitat suitability and the expected and observed population data for each wildlife habitat district (IEC Beak Consultants Ltd. 1985). An example of the evaluation legend format is provided in Table 1. This was a prototype study designed to develop methods which could be used to assess wildlife resource status on a provincial scale in an "assembly line" fashion. Two basic questions need to be answered in evaluating the results of the study: 1. Were the basic objectives met? 2. How could the methodology be improved to obtain better results?

Current Habitat Suitability Assessment

Both modelled and subjective manual assessments were obtained for all species except American marten. [The regional wildlife biologists did not have enough personal knowledge of the American marten to conduct an adequate subjective assessment]. Table 2 shows that the results of the two types of assessments were very different for all species. The

Table 1. Selected Examples of Wildlife Habitat District Evaluation Legend Data for Moose for the Rocky Mountain House (83B) Map Sheet.

Wildlife Habitat District	Manual Assessment	Modelled Assessment	Population Data (#/km²)			
			Expected[a]		Observed	
	Current Habitat Suit.	Current Habitat Suit.	Average	Range	Density	Variance[b]
4.03.01	3	2	0.6	0.4-1.0	0.1	<
4.03.06	3	2	0.6	0.4-1.0		U
4.18.01	4	3	0.3	0.1-0.4	0.0	<
6.05.01	2	2	0.6	0.4-1.0	0.6	0
8.68.01	2	2	0.6	0.4-1.0	0.5	0
8.68.02	1	1	1.5	1.0-1.9	2.1	>
8.68.03	1	2	0.6	0.4-1.0		U
8.68.04	3	2	0.6	0.4-1.0	0.2	<
8.68.05	2	1	1.5	1.0-1.9		U
9.13.01	3	2	0.6	0.4-1.0	0.8	0
9.13.02	2	1	1.5	1.0-1.9	0.3	<
9.13.03	2	2	0.6	0.4-1.0	0.1	<
9.22.01	3	1	1.5	1.0-1.9	0.3	<
9.22.02	3	1	1.5	1.0-1.9	0.2	<
9.22.15	2	2	0.6	0.4-1.0	0.5	0
9.22.16	1	1	1.5	1.0-1.9	1.1	0
9.22.17	3	1	1.5	1.0-1.9	1.1	0
9.22.18	2	1	1.5	1.0-1.9	0.2	<
9.26.06	1	2	0.6	0.4-1.0	0.6	0
9.27.05	1	2	0.6	0.4-1.0	1.9	>
10.06.01	3	1	1.5	1.0-1.9	0.4	<
10.06.04	3	1	1.5	1.0-1.9	2.9	>
10.06.08	2	2	0.6	0.4-1.0	0.2	<
10.06.09	2	1	1.5	1.0-1.9	2.3	>

[a] Expected population average densities and ranges shown are a constant function of current habitat suitability classes obtained from the modelled assessment.

[b] Variance codes are: < = observed less than expected, > = observed greater than expected, 0 = no significant difference between observed and expected, U = unknown variance due to the absence of observed density data.

Table 2. Number of Wildlife Habitat Districts to Receive Ratings of a Given Class Using the Modelled and Manual Assessment.

Species	Modelled Assessment				Manual Assessment			
	Best	Moderate	Poor	Inadequate	Best	Moderate	Poor	Inadequate
Moose	114	114	18	0	21	75	113	24
White-tailed Deer	221	25	0	0	1	41	120	70
Mule Deer	169	77	0	0	2	77	154	4
Elk	142	104	0	0	5	20	124	83
Bighorn Sheep	0	41	69	136	4	3	0	239
American Marten	68	65	113	0	Not Available			
Breeding Dabbler Ducks	52	187	7	0	0	0	120	126

modelled assessment consistently gave higher ratings of current habitat suitability than did the manual assessment.

It is perhaps easier to assume that the subjective assessments of expert biologist are more correct, particularly when some of the modelled assessments appear to be quite absurd; for example, bighorn sheep habitat in the Aspen Parkland region. This assumption has also been made in other studies where subjective evaluations by teams of experts have been used as a means of validating the accuracy of habitat assessment models (Mule 1982). However, there are also good reasons not to accept the subjective expert assessments as necessarily correct. Current habitat suitability as defined, should reflect habitat suitability in terms of food, cover and space, irrespective of the existing population density. However, it is very difficult to rate habitat suitability, from a subjective, impressionistic view, without considering existing population densities. In addition, it is difficult to subjectively rate current habitat suitability in a provincial context when assigning ratings to a single, regional map sheet. When comparing wildlife habitat districts within the map sheet, very few may be of a quality to rate as best for a given species. However, if the wildlife habitat districts are compared to all others in the province then they may in fact be best habitat. The converse may also be true.

In contrast, the modelled assessment may over-estimate current habitat suitability because of the tendency to over-rate the contribution of individual variable categories (e.g., coniferous forest as a vegetation variable category contributing to food) to given seasonal life requisites during the fall and winter. This results from the fact that many of the variable categories represent a broad range of actual conditions on the ground. For example, in the 83B map sheet area "coniferous forest" can represent any one of black spruce, white spruce, Engelman spruce, subalpine fir or pine cover types. Also no distinctions are made with respect to understory vegetation. When rating such a category there is a tendency to base the rating on the better habitat conditions which are known to occur within this highly variable range of conditions.

Other specific examples of possible problems with the modelled assessment can be found through careful comparison of the results of the modelled assessment and the habitat use data collected during the pellet group counts. For example, fall/winter food was the most important seasonal life requisite in the white-tailed deer species-habitat relationship model (i.e., it had the largest aggregation weighting value). However, the pellet group counts showed that the vegetation categories rated as best for fall/winter food (shrub/mixed herbaceous, perennial cropland and annual cropland) experienced little overwinter use whereas those categories that provided good thermal cover (coniferous forest) experienced heavy use. This indicates that thermal cover may be more important than food and, if so, the aggregation weightings in the model should be changed.

Another type of problem encountered in the modelled assessment is illustrated by the results for bighorn sheep. Within the map sheet, current sheep populations are limited in their distribution to two small areas of Subalpine/Alpine habitat and two Boreal Uplands wildlife habitat districts, however the modelled assessment predicted moderate and poor habitat throughout large portions of the map sheet. This discrepancy is probably a result of the fact that bighorn sheep have very specific habitat requirements that are represented by special features such as precipitous, inaccessible cliffs which are not adequately identified in the biophysical legend data base. In this situation suitable additions or improvements to the biophysical data base being used to drive the model could result in better model performance.

Knowledge of the juxtaposition, or spacial co-incidence, of certain categories of two or more variables may be required to properly assess habitat quality. Many of the wildlife habitat districts mapped at the 1:250,000 map scale are still quite heterogeneous, being represented in the biophysical legend by two or more categories of landform and vegetation cover. To assess bighorn sheep habitat it may be necessary to know not only that steep bedrock cliffs and herbaceous vegetation cover occur, but also that these features occur in proximity to each other within the larger heterogeneous map unit.

In general, neither the modelled assessment nor the subjective manual assessment provide ratings of current habitat suitability which are entirely satisfactory. Recommending specific changes to either assessment would require that known "real" current habitat suitability values be available that could be compared with the assessment results. However, current habitat suitability is a complex and conceptual aspect of wildlife ecology which cannot be directly measured in the field. Therefore validating the assessments would require identifying and measuring a parameter with a known relationship to current habitat suitability. Lancia et al (1982) have suggested that population distribution should be positively correlated with habitat quality. However, individual animals and populations can only alter their habitat utilization patterns in a local context and therefore population distribution at the wildlife habitat district level will reflect local, rather than provincial, variation in habitat quality. It is apparent that validation of a provincial assessment of current habitat suitability will require a long term program of sampling population density and that this sampling program must be stratified in such a way that the effects of non-habitat factors (e.g., hunting) can be accounted for.

Expected Population Densities

The objective of assigning an average expected population density (carrying capacity) and range of densities to each current habitat suitability class for each species was difficult to meet. For white-tailed deer and mule deer the species experts provided expected population densities. These average densities and ranges were based on a summary of population survey data and a subjective assessment of the degree to which non-habitat factors are suppressing observed populations.

For moose the species experts concluded that in the absence of information about the nature and magnitude of non-habitat factors which reduce the population densities below theoretical carrying capacity the only estimates that could be obtained were actual average density estimates and ranges for each class based on existing population survey data and data collected for this study. For elk, the species experts concluded that it was not possible to attempt to estimate the density of animals that would be found in a wildlife habitat district at carrying capacity. Because elk are highly gregarious, mobile and have large home ranges, it is nearly impossible to provide meaningful densities related to carrying capacity. It was concluded that for bighorn sheep, American marten and breeding dabbler ducks there was insufficient information to even attempt to assign expected population densities.

Observed Population Densities

Existing population survey data, available primarily from the Fish and Wildlife Division (AENR), was found to be of little value in estimating observed population densities for individual wildlife habitat districts. The primary difficulty was that the data was not collected within the context of the wildlife habitat district map and as a result the data either could not be converted to a wildlife habitat district basis or the sample size for each district was so small that reliable density estimates could not be obtained.

The amount of new data that could be collected to estimate observed population densities was limited by the time and budgetary constraints of the study. As a result, no attempt was made to collect density data for bighorn sheep or American marten. For breeding dabbler ducks the data obtained by a single aerial survey was of questionable value, primarily because of the very low densities encountered at the time of the survey (0.2-1.6 breeding pairs per km^2). Better quality data could be collected if water body surveys were conducted rather than line transect surveys, however it would be difficult to convert water body surveys to density estimates on a wildlife habitat district basis.

The ungulate density data collected suffered from two shortcomings. First, both aerial survey data and the pellet group data for elk exhibited an extremely clumped distribution among wildlife habitat districts. The resulting density estimates vary widely in an apparently random fashion. A substantially increased level of effort would be required to alleviate this problem. Secondly, the pellet group count data for deer could not be differentiated by species. This resulted in difficulties in presenting and interpreting the deer density estimates.

CONCLUSIONS AND RECOMMENDATIONS

1. Substantial refinement of the methods of assessing current habitat suitability as required:
    a) The subjective manual assessment needs to be more structured with appropriate background and briefing materials to ensure that these assessments reflect current habitat suitability irrespective of population distribution and abundance.
    b) The results of the modelled assessment might be improved if the assessments are conducted using an iterative process in which changes to the models are based on field sampling which has been stratified on the basis of initial habitat assessments.
    c) Assessments of current habitat suitability for wide ranging species such as elk and grizzly bear may be of more value if they were conducted using an ecological unit which was comparable in size to the home range size of the species. A suitable unit may be the habitat subregion.
    d) Assessment of current habitat suitability for species with highly specific habitat requirements, such as bighorn sheep, will necessitate that a description of large scale, site-specific habitat features be included in the biophysical data base. It may not be possible to include such features in a general data base prepared at the scale of 1:250,000.
2. Because there is no theoretical or research base from which to estimate expected population (carrying capacity) densities the subjective process by which these estimates are arrived at should be standardized as much as possible.
3. The field programs used to obtain information on observed population densities will have to be specifically tailored for each map sheet (study area) that is assessed. Development of suitable field programs should consider

such factors as the priority species of concern and the access available for field crews.

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WILDLIFE RESOURCE EVALUATION AND LAND/WILDLIFE RELATIONSHIP MODELS

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INTRODUCTION

Society views wildlife as an important natural resource having economic, social and ecological value. Good management of the resource, so as to optimize these wildlife-related values, requires information concerning the distribution, abundance and quality of wildlife populations and habitats through space and time. Assessments of these resources are ultimately part of an overall information management system designed to acquire and organize knowledge in a way that will enable and give direction to human action.

Wildlife resource evaluation is the process of assigning value to defined geographic areas based upon the occurrence (potential or realized) of particular wildlife populations. The purpose of such evaluations is to determine socio-economic and ecological values of the wildlife resource as a basis for management decisions. These decisions may be directly related to the resource, as in the case of establishing hunting regulations and recreational viewing opportunities, or they may be indirect as in the case of developing forest harvest plans or implementing agricultural expansion through wetland drainage. In either case informed management decisions require evaluations which clearly and succinctly identify the relative importance of different areas to identified wildlife species of management concern. Management decisions may not only require information on how important an area is but also why it has a certain level of importance. Knowledge of the causal factors associated with particular wildlife resource values will enable minimization of potential development impacts and identification of mitigative or enhancement opportunities.

WILDLIFE RESOURCE EVALUATIONS

The evaluation process may focus directly upon measurements of particular wildlife populations to assess their distribution and abundance on a seasonal or year-round basis. These population measurements are usually based upon sampling procedures that involve direct, or indirect in the case of animal sign, observations of a portion of the population occurring within defined areas.

In contrast to direct attention to wildlife populations, many wildlife resource evaluations examine the condition or status of the habitat. Habitat is defined here as the biophysical environment (including climate) which provides or detracts from the essentials of food, cover and space as needed for a population of animals to reproduce and maintain itself. Wildlife habitat evaluation therefore involves the measurement and analysis of habitat components for the purpose of determining the potential of a given geographic area to support particular wildlife populations.

For many wildlife species it is easier to measure and evaluate habitat and associated population potential than to attempt to accurately measure and estimate actual population levels. Some of the reasons for this are:

1) Animal populations fluctuate substantially through time and space.

2) Most animal populations are not amenable to remote sensing techniques and many are very difficult to observe directly and reliably through survey sample techniques.

Some of the more common types of wildlife resource evaluation may be categorized and defined as follows:

Population Status Assessments

1. **Current Population Status:** Actual or estimated population levels within defined geographic areas (land units) as determined by direct or indirect sampling of animal numbers. These counts may serve as a basis for estimating population levels in unknown and unsampled areas. Considerable variability is usually associated with population estimates, therefore sampling procedures and confidence limits should be indicated. Many population surveys provide only a relative index of population abundance as opposed to absolute densities or total numbers. These latter surveys are designed to monitor population fluctuations over time.

2. **Critical or Key Area Designations:** The identification of localized areas which have been observed to support large concentrations of animals for certain periods of the year, or which provide essential life requisites needed for the maintenance of the population over it's larger range. For example, these may be wintering areas, nesting or fawning habitats, migration corridors, or feeding concentration areas. The relative susceptibility of these areas and associated wildlife populations to human disturbance may be a factor in their designation as critical or key areas. Such designations may appear to be habitat assessments; however, they are frequently the result of population observations as opposed to habitat analysis. In fact, observations of high levels of localized animal use may reflect traditional behavioral factors more than any obvious habitat factors.

Habitat Status Assessments

1. **Current Habitat Suitability:** Identifies the current ability of a land unit to provide a wildlife species with the environmental conditions needed for food, cover and space. This assessment is current-time specific and would reflect existing vegetation cover as influenced by natural and man-caused disturbance.

2. **Inherent Habitat Capability:** Identifies the natural or inherent ability of a land unit to provide a wildlife species with the environmental conditions needed for food, cover and space. This assumes little or no interference by man, with natural vegetation cover being present and representative of a relatively stable climax or disclimax type. The Canada Land Inventory (CLI) for ungulate capability and waterfowl capability represents this type of habitat assessment (Perret 1969).

3. **Potential Habitat Capability:** Identifies the potential ability of a land unit at some future point in time to provide a wildlife species with the environmental conditions needed for food, cover and space. This assessment is based upon a knowledge of the range of potential future environmental conditions that may occur in a given area as a result of predictable man-induced or natural vegetation successional changes.

The ungulate and waterfowl capability classifications conducted as part of the Canada Land Inventory (CLI) would seem to best correlate with the above definition for inherent habitat capability. CLI placed considerable emphasis on physical landscape characteristics and the "natural state" of the land, irrespective of present cover (Perret 1970). However, more specific reference to the actual application of CLI ungulate capability classification indicates that ratings are based upon the optimum natural vegetation stage (successional stage) which could be maintained with non-intensive management practises (Blower 1973). A major problem exists with the ambiguous terminology of "non-intensive management", which does not appear to have been clearly defined within the CLI context. More recent wildlife capability classification work in British Columbia, which evolved out of the CLI program, defines non-intensive management as including prescribed burning or logging (Demarchi et al 1983). This latter perspective on capability classification would therefore more correctly fit within the above definition for "potential habitat capability". The point to be emphasized here is that a variety of possible potential habitat capabilities can occur for a particular species and landscape area. For example, it is conceivable that a high potential habitat capability could exist within an area for both woodland caribou and moose, but never at the same time due to the very different vegetation succession stages preferred by each species. Any assessment of this nature must clearly spell out the disturbance or management conditions and time frames under which such an assessment is being made. An environmental impact assessment does this when it tries to predict post-development habitat conditions which can be compared against pre-development conditions (current habitat suitability). Inherent habitat capability may be considered as just one of the many possible potential habitat capabilities that can exist within the natural vegetation chronosequence.

Population potential or carrying capacity is frequently estimated for the above noted habitat assessments since wildlife managers are ultimately concerned with how these habitat measurements and evaluations translate into numbers of animals. Environmental impact assessment techniques such as the U.S. Fish and Wildlife Habitat Evaluation Procedures (HEP), frequently use a comparison of current habitat suitability (before development) with potential habitat capability (after development) to determine the impacts to wildlife habitats and populations from proposed development scenarios (U.S. Fish and Wildlife Service 1980).

It must be clearly recognized that calculations of population potentials using habitat suitability assessments are not a prediction of actual populations. Many other non-habitat factors such as predation, disease, hunting and other direct human disturbances could be affecting actual population levels.

Multiple Species Occurrence Assessments

Increased concern with non-game wildlife species in recent years has resulted in assessments directed towards presence/absence ratings and species/habitat diversity measurements. The relationship between the life requisite needs for feeding and reproduction of a wildlife species and the vertical vegetation structure within a particular cover type and climatic region, can be used as a basis for determining the potential presence or absence of individual wildlife species or groups of wildlife species (guilds) which have overlapping habitat requirements (Short 1984, Thomas 1979). The management concern underlying many of these assessments is usually two-fold:

1. Rare, endangered and threatened wildlife species must be maintained at, or increased beyond, existing population levels and distributions.
2. Wildlife species diversity is desirable and reflects a healthy and stable environment, as well as increasing recreational opportunities for the public.

These two perspectives can frequently be at cross purposes since many rare and endangered species are associated with low diversity, late seral communities of plants and animals.

A review of wildlife resource assessment techniques during the past 10 to 15 years shows an increasing reliance upon habitat evaluations, as opposed to direct population measurements (Eccles and Stelfox 1985). This is particularly true of environmental impact assessments where conditions before and after development need to be compared. Also, assessments for the purpose of making public declarations on resource status and trends, and for aiding wildlife management decisions and planning priorities are frequently dependent upon habitat evaluation as an indirect measure of estimating population levels and trends. As previously mentioned, one of the reasons for this shifting emphasis is the difficulty and cost associated with obtaining good quality population data. Another reason is that more of the wildlife manager's attention is being directed at people management and land management as indirect means of managing wildlife populations. Both ecological land surveys and land/wildlife relationship models offer considerable potential in aiding the required evaluations of wildlife resources.

LAND/WILDLIFE RELATIONSHIP MODELS

Wildlife resource evaluations must use well defined, repeatable and quantifiable procedures if the results are to have credibility with resource managers. The need, and in some cases legal requirement, to quantify wildlife resource values has resulted in substantially increased effort during the past several years to model land/wildlife relationships. The following discussion outlines some of the basic precepts, characteristics and difficulties associated with habitat evaluation models, as well as offering some guidelines for their development and application.

All habitat evaluation models rely on the assumption that habitat factors such as vegetation, soils and surface water features can be identified which influence an area's ability to supply a wildlife species with it's life requisites such as food and cover. Furthermore, it is assumed that the correlations between habitat factors and life requisites can be structured within predictive models so as to establish quantifiable relationships needed to assess the relative or absolute value of an area to a wildlife species.

Model Objectives

The first step in the development of land/wildlife relationship models is to clarify the model objectives and desired outputs. The type of numerical scores or habitat class designators that are desired as end products should be identified at the outset. Also, the scope of the modeling process must be known in terms of the wildlife species to be considered and the geographic area to which the model is applicable. Models should be specific to those portions of a species range where habitat preferences are known to be similar. Separate models may have to be developed for some species at an ecoregion level of specificity where it can be assumed that the animals adaptation and response to it's environment is more or less constant and definable. Bailey (1976) defines an ecoregion as a "... geographical area over which the environmental complex, produced by climate, topography, and soil, is sufficiently uniform to permit development of characteristic types of ecologic associations". The geographic applicability of a model must be clearly defined.

Model Components

A second step in the development of land/wildlife relationship models is the assimilation of knowledge concerning a wildlife species' ecology and it's habitat requirements and preferences relevant to the area under study. This usually involves a thorough review of the literature, unpublished fish and wildlife file data and consultation with local species experts. Considerable care must be taken in utilizing research information collected from other geographic regions which may not be applicable to local and regional study area conditions. Also seasonal variation in habitat requirements should be identified.

Habitat requirements should be documented in the context of life requisites such as food, cover and space. Cover may be further broken down on the basis of thermal cover, escape or hiding cover and reproductive cover. These life requisites must be described in such a way that they can be associated with biophysical factors which lend themselves to classification and measurement. Table 1 outlines the format of habitat requirement summaries developed for selected wildlife species in Alberta (Nietfeld et al. 1984). The summaries become part of the model documentation and provide supporting justification for the model design. Similar summaries form an integral part of the HEP models (U.S. Fish and Wildlife Service 1981).

TABLE 1.

Outline For Habitat Requirement Summaries Of Selected Wildlife Species In Alberta.*

General

Cover
- Vegetation
- Landforms and Topography
- Aquatic Forms
- Climate

Food
- Vegetation
- Landforms, Topography and Soils
- Aquatic Forms
- Climate

Space
- Home Range
- Population Distributions and Densities

Special Considerations
- Size, Shape and Juxtaposition of Habitat Components
- Significance of Disturbance Phenomena

Limiting Factors

Regional Variations

*Adapted from Nietfeld et al. 1984.

As a result of this review of a species habitat requirements it will be possible to select a few habitat factors or biophysical variables that are strongly correlated with the provision of a particular life requisite and that can be measured in a cost effective manner. For example, the percent composition of conifer trees in the forest canopy may be a good measure of the degree of thermal cover available to moose in forest cover types. Depending on the study it may be necessary to select only variables that can be identified and measured through remote sensing. An attempt should be made to select only a few variables that are considered to be the best indicators or predictors of life requisite habitat conditions. It may also be desirable to focus on only a particular season of the year that is considered essential to the continued survival of the species within the study area.

The U.S. Fish and Wildlife Service (1981) recommends using the following criteria for identifying suitable model variables:

1. ... "the variable is related to the capacity of the habitat to support the species,"
2. ... "there is at least a basic understanding of the relationship of the variable to habitat (e.g., what is the best and worst conditions for the variable and how does the variable interact with other variables?)" and
3. ... "the variable is practical to measure ...".

It may be helpful to use a tree diagram such as shown in Figure 1 to identify useful model variables. This approach separates habitat requirements into less complex components, each of which can be related to a set of measurable variables. The final selection of model variables should be justified by the habitat requirements previously documented.

Model Structure and Operation

The third step in developing models is the actual structuring of quantifiable relationships between the biophysical variables and other significant model components already identified so that an overall habitat suitability evaluation can be achieved. The development of a tree diagram as shown in Figure 1 begins this structuring process by showing which variables will be used to evaluate a particular life requisite and which life requisites will be used to evaluate seasonal habitat requirements and finally year-round habitat requirements for a particular wildlife species. It must then

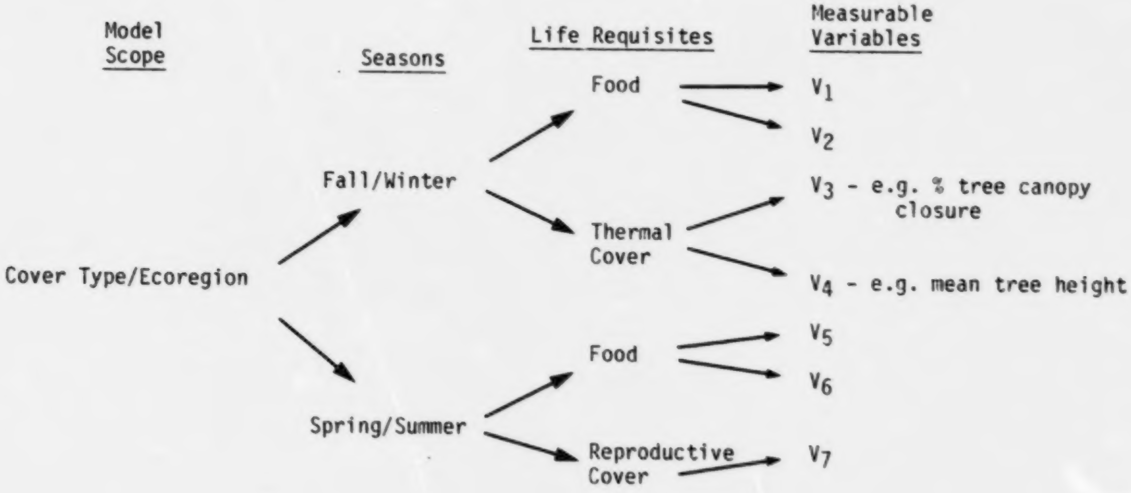

Figure 1. Identification of model variables on the basis of seasonal life requisite needs for a particular wildlife species and cover type or ecoregion.

be decided how numerical suitability measurements, ratings, or scores, are to be calculated for each variable. This may involve the use of ranking procedures for a range of potential variable categories as in the case of the Alberta species-habitat relationship models (Table 2) or the use of habitat suitability index graphs as in the case of HEP models (Figure 2). Once numerical scores or ranks have been determined for individual variables, the model must define the quantitative relationship between these variables so that a single overall habitat assessment value can be achieved. A variety of descriptive and mathematical approaches can be used. An excellent review of various approaches, including: word models, mechanistic models, pattern recognition models, Bayesian probability models, and multivariate statistical methods, is provided in Standards for the Development of Habitat Suitability Index Models (U.S. Fish and Wildlife Service 1981). Some of the important questions or considerations in defining the relationship between variables within a model include:

1. Should some variables carry more weight or importance than others? An example of variable, life requisite and seasonal habitat weighings is shown for the Alberta Fish and Wildlife Division models in Figure 3.

2. Should low scores for some variables be limiting to the overall habitat suitability or can they be compensated for by other variables? The use of limiting factor or compensatory relationship considerations in a model must be based on a sound understanding of a wildlife species' ecology. These habitat component relationships must be structured into the model mechanics and mathematical calculations used.

3. Should the size and proximity of adjacent vegetation cover types or landscapes units influence the habitat suitability rating? Wildlife species with relatively large home ranges are likely to find their food and cover needs, or their seasonal habitat needs, in quite different cover types or landscape types. This may require the use of juxtaposition or interspersion indices in the modeling process.

Model Documentation and Validation

The fourth step in model preparation is the documentation on how the model has been constructed and how it operates. This should include identification of assumptions and rationale used, the scope and objectives of the model and the limitations of its applicability and accuracy. Finally, all models should be subjected to some form of validation and field testing. Meaningful accuracy verification is a major problem since observed population data is frequently not a reliable indicator of habitat quality (Van Horne 1983). Most accuracy validation at present relies on a comparison of the model results with a subjective assessment by species experts (Mulé 1982).

TABLE 2. Example Variable Ranking in Species/Habitat Relationship Model for Moose in Alberta. (From Stelfox 1984 as adapted from IEC Beak Consultants Ltd. 1984).

Species: Moose
Seasonal Habitat: Fall/Winter
Life Requisite: Food
Variable: Vegetation Cover

Variable Ranking (Value)	Variable Category	Rationale/Reference
Inadequate (0)	NW (Non-vegetated Water) NM (Non-vegetated Mineral) NA (Non-vegetated Anthropogenic) AE (Aquatic Emergent) HM (Herbaceous Mixed) C (Cultivated Cropland) CA (Annual Cropland) CI (Irrigated Cropland) CP (Cultivated Perennial Forage)	Non-vegetated categories offer no food. Moose are primarily browsers in the winter; therefore, categories without a woody vegetation component are are ranked inadequate.
Best (3)	S (Shrub) S/HM (Shrub/Herbaceous Complex) FD (Deciduous Forest)	Those categories which provide the greatest amounts of deciduous trees and shrubs for browse (1, 9, 10)*.
Moderate (2)	HM/S (Herbaceous/Shrub Complex) FMD (Mixedwood Forest-deciduous dominant) PD (Deciduous Parkland) M (Muskeg)	Shrubs are very important as a food source (10,11); therefore, HM/S is ranked moderate although the shrub coverage may be small. The other categories are ranked as moderate or poor because they have a progressively smaller deciduous tree and shrub component.
Poor (1)	GD (Deciduous Groveland) FC (Coniferous Forest) FMC (Mixedwood Forest-coniferous dominant)	

*Numbers in parentheses under rationale refers to specific items of information from the key habitat requirements summaries appended to each model.

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APPLICATION OF SATELLITE DATA AND IMAGE ANALYSIS TO WILDLIFE HABITAT INVENTORY

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INTRODUCTION

The identification, mapping, assessment and management of vegetation types as habitat for wildlife has always been an important role for the wildlife biologist. Remote sensing techniques provide excellent tools for dealing with large ecological units, especially data from satellites.

Remote sensing is an old concept which is receiving new attention with the availability of satellite data and sophistication and improvement of computer analysis. Data from new sensors with greater spectral sensitivity and resolution on board new satellites are now offered making this type of data even more applicable to wildlife habitat analysis.

This paper outlines state of the art satellites, data, and image analysis with a number of case studies on wildlife habitat analysis over the past five years. This paper is confined to satellite data and analysis since other remote sensing technologies applied to wildlife habitat analysis have been reviewed by Adams (1978), Tueller (1980), and Mayer (1984).

STATE OF THE ART SATELLITE DATA AND IMAGE ANALYSIS

The first earth resources satellite was launched in July 1972 and followed by four more. Each of these satellites was in a near-polar, sun-synchronous orbit travelling north to south during the daylight hours passing over any given part of the earths surface at the same local time on every pass. Fourteen orbits are completed each day with 2752 km between orbital paths (Figure 1 a,b). The period for the first three satellites was approximately 104 minutes at an altitude of 920 km. With a lower orbital altitude of 705 km it only took 99 minutes for the last two, Landsat 4 and 5, to orbit the earth. The first three Landsat satellites produced an image of any given part of the earths surface, baring cloud cover, every 18 days. Landsat 4 and 5 individually have a repeat cycle of 16 days. Since Landsat 4 was still functioning when Landsat 5 was launched, it was arranged that the 16 day repeat cycle for each satellite would overlap so as to give repetitive coverage of any given area every 8 days (Table 1).

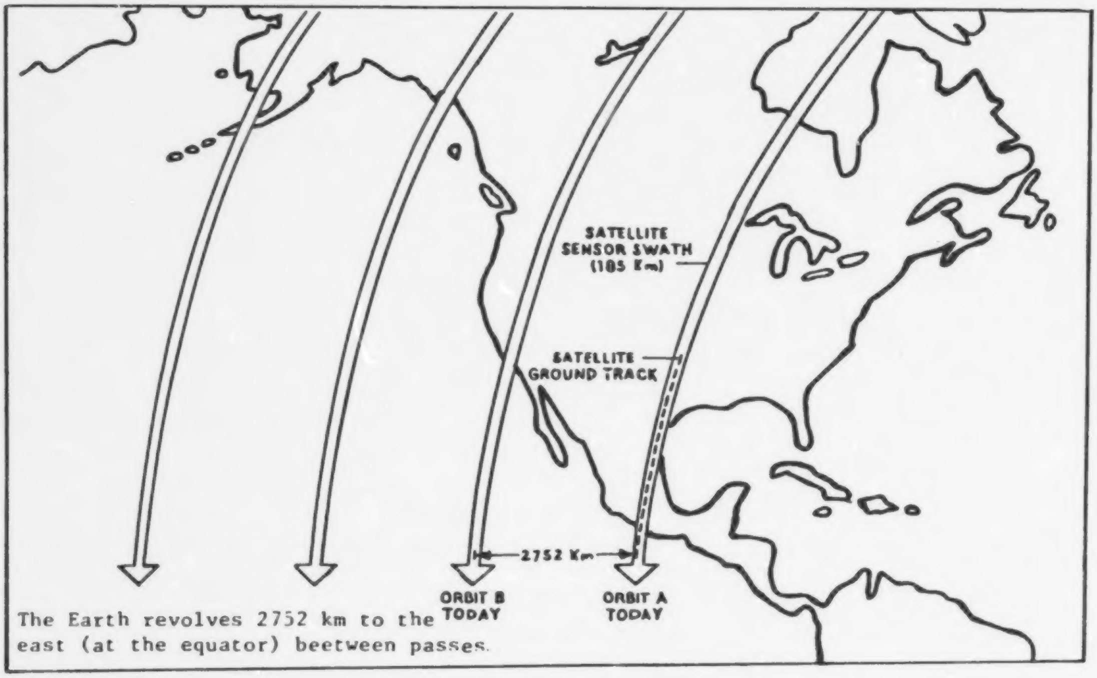
The prime sensor on board all 5 satellites, the Multi Spectral Scanner (MSS) has remained unchanged. With Landsat 4 and 5 an additional sensor, the Thematic Mapper (TM) was added. Since the main concern of this paper is present operating satellites and their sensors these will be dealt with in more detail.

Multi Spectral Scanner Data (MSS)

The multi spectral scanners which continually scan a 185 km swath on the earths surface have remained unchanged in all 5 satellites. Scanning is done in a cross-track direction by an oscillating mirror with six lines scanned simultaneously in each of the four spectral bands for each mirror sweep (Figure 2). The forward motion of the satellite provides the along-track progression of the scan lines. This scanning along the track is continuous and the data is only transformed into framed images of 185 x 185 km on the ground at an image processing facility. The resolving power of the MSS sensors on the ground is 60 x 83 m which represents one picture element or pixel. The four MSS bands and potential uses are given in Table 2.

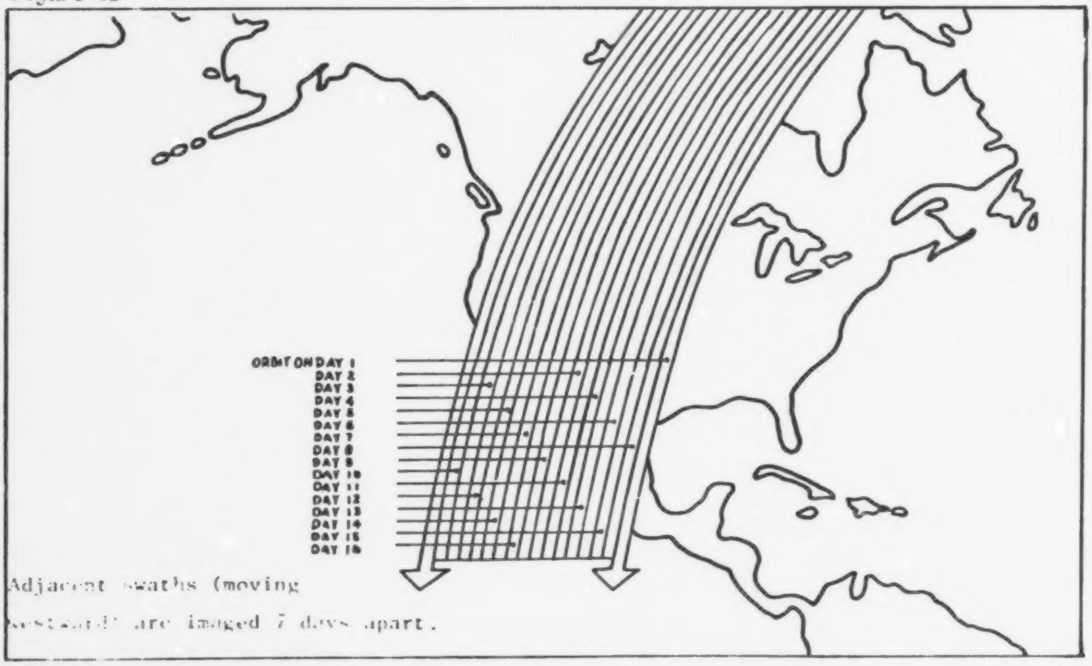
The data received from the Landsat satellite at a ground receiving station is on a high speed 28-track High Density Tape (HDT). This data must then be transformed into a computer compatible tape and corrections for mirror velocity, earth rotation, spacecraft attitude and variations in sensor response (radiometric error) made. At the Prince Albert Satellite Station (PASS) a quick-look system lets you view imagery as it is being recorded from the satellite. Microfiche is then produced and is available to users within a very short period

Figure 1a


SATELLITE
SENSOR SWATH
(185 Km)
SATELLITE
GROUND TRACK
2752 Km
ORBIT B
TODAY
ORBIT A
TODAY

The Earth revolves 2752 km to the east (at the equator) beetween passes.

Figure 1b


ORBIT ON DAY 1
DAY 2
DAY 3
DAY 4
DAY 5
DAY 6
DAY 7
DAY 8
DAY 9
DAY 10
DAY 11
DAY 12
DAY 13
DAY 14
DAY 15
DAY 16

Adjacent swaths (moving westward) are imaged 7 days apart.

Table 1: The Landsat Series

		1	2	3	4	5
ALTITUDE	miles	572	572	572	438	438
	kilometres	920	920	920	705	705
PERIOD	minutes	104	104	104	99	99
CYCLE	days	18	18	18	16	16
RBV		1 - .475-.575 2 - .580-.680 3 - .698-.830	same	A,B, panchro	-	-
MSS		4 - .5-.6 5 - .6-.7 6 - .7-.8 7 - .8-1.1	same	same	1 - .5-.6 2 - .6-.7 3 - .7-.8 4 - .8-1.1	same
RESOLUTION		56 x 79 m	same	same	60 x 83 m	same
TM					1 - .45-.52 2 - .52-.60 3 - .63-.69 4 - .76-.90 5 - 1.15-1.75 6 - 10.4-12.5 7 - 2.06-2.35	same
RESOLUTION					30 x 30 m	

ERTS - 1 - July 1972 - January 1978
LANDSAT - 2 - January 1975 - February 1982
LANDSAT - 3 - March 1978 - April 1980 - intermittently thereafter
LANDSAT - 4 - July 1982 - Ongoing (except TM)
LANDSAT - 5 - March 1984 - Ongoing

Table 2: MSS Functions and Potential Uses

Bands	Range (µm)	Principal Applications
4	0.5 - 0.6	Detection of cultural features, vegetation classification, geological classification, turbidity in water.
5	0.6 - 0.7	Discriminating vegetation types, cultural features, turbid water detection.
6	0.7 - 0.8	Identify water characteristics, detection of conifer and deciduous forests.
7	0.8 - 1.1	Identification of wet soils, standing water bodies in relation to band 6. Maximum reflectance from vegetation, detection of blight and insect infestations in crops and forests.

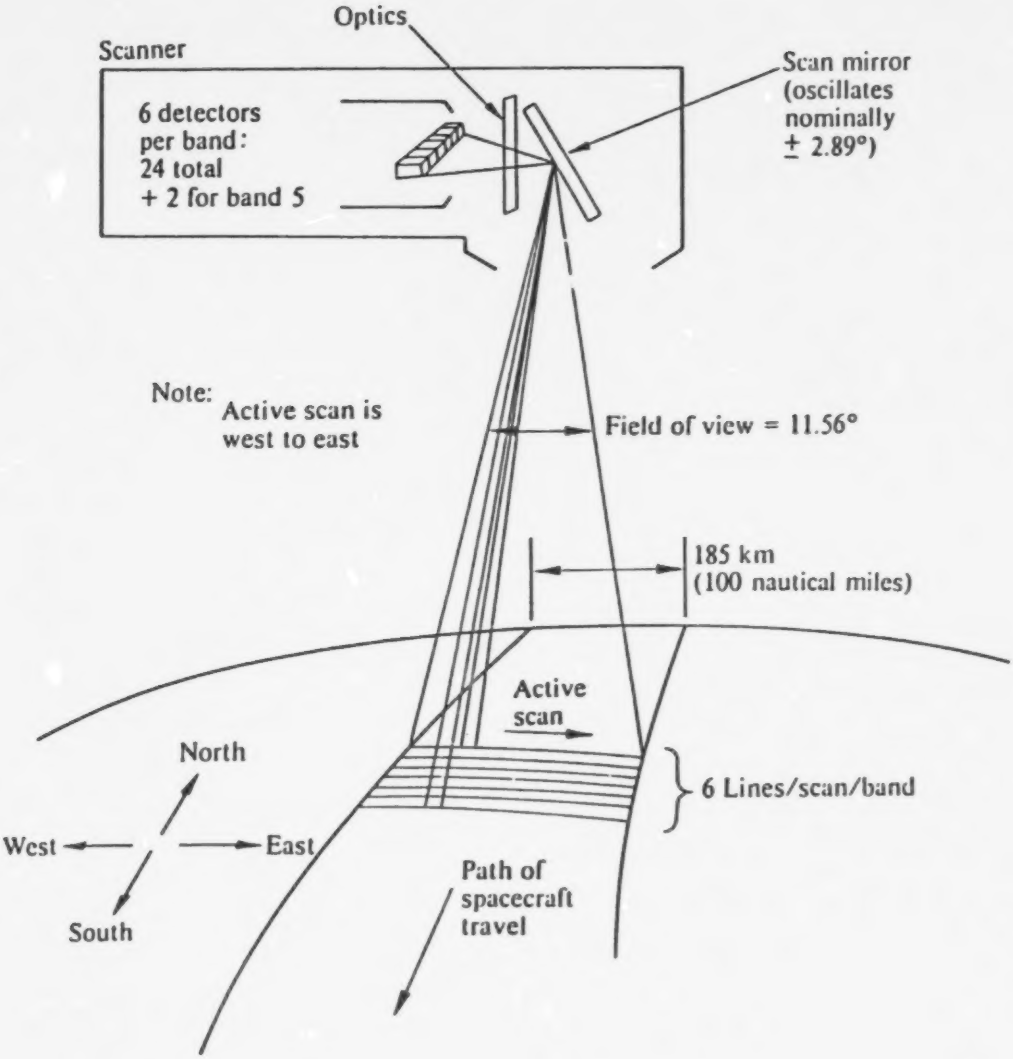

Optics
Scanner
6 detectors per band: 24 total + 2 for band 5
Scan mirror (oscillates nominally ± 2.89°)
Note: Active scan is west to east
Field of view = 11.56°
185 km (100 nautical miles)
Active scan
North
West
East
South
6 Lines/scan/band
Path of spacecraft travel

Figure 2: Landsat MSS.

of time. Computer Compatible Tapes (CCT) are produced from the high density tapes on demand as well as photographic products (Table 3).

Thematic Mapper Data (TM)

The Thematic Mapper sensors are more advanced than the MSS, having higher spectral, radiometric, and geometric sensitivity. The TM sensors consist of seven bands, three within the spectral range of the MSS from green to reflective infrared. Two new bands cover the blue and mid-infrared while a third new band is in the thermal infrared region. The green and red bands are narrower than the MSS to improve sensitivity to spectral changes in agricultural crops. The reflective infrared band is narrower than the combined MSS bands of 6 and 7 to maximize sensitivity to plant vigor (Table 4). The new blue band (band 1) was included to provide data in the field of bathymetry and assist in stress evaluation of agricultural crops.

The resolution of the TM is about 2.6 times that of the MSS with a pixel size of 30 x 30 m, ground resolution in all but band 6 which has a ground resolution of 120 m. TM's greater number of spectral bands, higher radiometric sensitivity and higher resolution contribute to a larger amount of data. One MSS scene, using the band interleve by line format, of 185 x 185 km can be put on one 2400 ft, 1600 BPI computer tape. The same area covered by the TM sensors and using the same tape format requires twelve tapes. MSS, with four bands, requires 32,918,400 bits of information to cover one scene. TM requires 247,296,000 bits of information in six bands, not including the thermal infrared, to cover the same area. For practicality the TM data is therefore designated in quarter scenes relative to one whole MSS scene. Photographic products are obtainable the same as MSS data (Table 3) but each print refers to one quarter of an MSS scene. In digital data one quarter is contained on three computer tapes.

When Landsat 4 was first put into orbit in July 1982 both MSS and TM sensors functioned well. Unfortunately the TM sensor developed problems approximately three months later and was turned off although MSS data continued to be provided. On March 1, 1984 Landsat 5 was launched in a half-cycle relationship to Landsat 4 to double the data acquisition capability over a given area. Any given area could therefore be imaged every 8 days but only with the MSS. TM data can only be obtained from Landsat 5 every 16 days at the present time.

One problem which is prevalent to TM data is a line jitter which is particularly noticeable on linear features running north-south. A number of lines may be offset by two or three pixels. This offset is due to a combination of factors. On the MSS the active scan of the mirror is only in one direction, from west to east. The TM scan mirror is active in both directions. Combining this with the MSS scan mirror and the movement of the high gain antenna which continually aligns itself with the Tracking Data Relay Satellites (TDRSS) causes the line jitter in the data. Work has started in trying to solve this problem.

At this moment TM data in CCT form is not that readily available in Canada due to the lack of a high speed processor. Only four full scenes can be processed at CCRS in Ottawa per week. By mid 1986 a high throughput precision image correction facility (MOSAICS) will be installed at the satellite receiving station at Prince Albert and in Ottawa. This sytem will handle MSS, TM, and SPOT data at a much faster rate than the present system.

Specialized Products

Beside the standard photographic or computer tape products obtainable from the Prince Albert Satellite Station a number of specialized products have also been developed. The raw data on a standard CCT is skewed and distorted. Most users would prefer this data to conform to a standard map so that the imagery can be integrated with other geobased information systems. A precision processed image product based on the Universal Transverse Mercator (UTM) projection is offered to users. The imagery is geometrically corrected and rotated to align the pixels to the UTM grid. The pixels are resampled to 50 metres square and the images divided and reframed into 0.5^{o} latitude by 1.0^{o} longitude quadrangles corresponding to four 1:50,000 map sheets or one quarter of a 1:250,000 map sheet.

A rangeland enhancement is obtainable from PASS which has set reflectance limits in band 4 (1-19%), band 5 (2-21%) and band 7 (8-28%). These limits were designed to emphasize subtle differences in ground cover types in the mixed-grass prairie (Ahern 1983). Features of interest to range managers such as heavily and lightly grazed areas, fields seeded to tame pasture, sacrifice areas, water development, saline blowouts, and cross fencing can be more easily identified.

The mixed-wood enhancement is for forest areas containing 20% to 30% of leaf-out deciduous trees. This enhancement produces a high-contrast image showing a number of ground features distinctly with a special sensitivity to broad leaf vegetation. It is also useful in

Table 3: Photographic Satellite Products

Black and white prints and transparencies

1. 70 mm - 4 band film strips - negative or positive
2. 185 mm - paper prints - 1:1,000,000 scale
3. 185 mm - film transparency - positive - 1:1,000,000 scale
4. 371 mm - paper enlargements - 1:500,000 scale
5. 371 mm - positive film enlargements - 1:500,000 scale
6. 742 mm - paper enlargements - 1:250,000 scale

Colour prints and transparencies

1. 185 mm - paper prints - 1:1,000,000 scale
2. 185 mm - positive transparencies - 1:1,000,000 scale
3. 371 mm - paper enlargements - 1:500,000 scale
4. 371 mm - positive transparencies - 1:500,000 scale
5. 742 mm - paper enlargements - 1:250,000 scale

Microfiche

Table 4: TM Functions and Potential Uses

Bands	Range (μm)	Principal Applications
1	0.45 - 0.52	Water body penetration, coastal water mapping, soil/vegetation differentiation, deciduous/conifer differentiation.
2	0.52 - 0.60	Vigor assessment of vegetation.
3	0.63 - 0.69	Chlorophyll absorption for plant species differentiation.
4	0.76 - 0.90	Biomass content, water body delineation.
5	1.55 - 1.75	Vegetation moisture content, soil moisture, snow/cloud differentiation.
6	10.4 - 12.5	Thermal mapping, vegetation stress analysis, soil moisture discrimination.
7	2.08 - 2.35	Discriminating rock types, hydrothermal mapping.

determining the relative ages of clear-cuts while information about other types of ground features can also be extracted such as bogs, bare ground, roads and water.

The softwood enhancement is for forest areas containing less than 20% leaf-out deciduous trees. The enhancement produces a high-contrast rendition sensitive to subtle vegetation differences in conifer density, small amounts of deciduous vegetation and vigorous, young coniferous growth. It also accentuates topographic effects which must be taken into account when doing interpretation (Ahern, 1984).

The above enhancements are used in visual interpretation usually from a photographic print at various scales. Sharp boundaries between broad leaf vegetation and conifers, different cutting patterns, relative ages of clear cuts, emphasis of property lines, and areas of regeneration can be identified. Since the imagery incorporates vegetation and soil types, morphological, climatic and hydrological data, biophysical mapping can be undertaken over large areas (Harvey, Cihlar, Goodfellow, 1982).

Digital Analysis

Interpretation of satellite data can be done visually, as one would an aerial photograph, using either the raw data in photographic form or through some of the specialized photographic products described above. Computer processing of satellite data adds several dimensions which are not possible through visual interpretation. The raw data has a number of geometric distortions which can be corrected to a Universal Transverse Mercator (UTM) grid through a number of ground control points derived from maps. The pixels are also resampled to match the correct geometric coordinates. The enhancements described above may not meet the requirements necessary for visual interpretation and so image enhancement may be performed to increase the contrast. Linear contrast stretching is the simplest contrast enhancement. The raw data in each of the four MSS bands may have only a narrow range of brightness values. By stretching this narrow range lineally over 256 values from black to white increases the detail in possible areas of uniform grey. Other enhancements such as uniform distribution stretch, Gaussian stretch, density slicing, edge enhancement, spatial and directional filtering, and enhancement by principal components may be used singly or in combination dependent on image area and quality. Most of these are standard algorithms on image analysis systems such as the ARIES II and III produced by DIPIX Ltd. in Ottawa.

Once the data has been enhanced visual interpretation can be done either on the screen or on a photographic hard copy product produced from the visual display unit.

Classification of an area into vegetation, land use, or geomorphic types is considered by some to be the ultimate goal of image processing. Each pixel in a Landsat image is characterized by its spectral signature in four different wave lengths. Classification is an information extraction process that assigns pixels to categories based on similar signatures. Supervised and unsupervised classification are two approaches commonly used in image processing. In unsupervised classification the computer analyses the data and selects the most significant groups based solely on the natural clusters it finds in the reflectance values. It may delineate natural land cover changes which may be useful where the analyst has no independent information about the area. Once the process is complete the analyst must examine the classes and attempt to decide what they represent. Very often the groupings do not coincide with what the analyst had expected.

Supervised classification on the other hand uses independent information to define training data that are used to establish classification categories. The analyst delineates small homogeneous areas of known ground cover. The comptuer is then instructed to search the entire image and group all areas with similar reflectance values into a single class. In this way the analyst is assured that the image will be classified into distinct classes that he requires. Supervised classification does take more time and the prerequisite of a prior knowledge of the study area. On the other hand classified imagery is more highly correlated to land use maps or other maps derived by conventional means. Also pixels which do not fall within any of the training areas outlined are considered unclassified. After classification a table of areal coverage of each of the classes can be produced in hectares, number of pixels, and percentage of the area classified.

CASE STUDIES

The five case studies outlined below cover habitat mapping for birds and mammals in North America and abroad and will hopefully give the reader a cross-section of satellite uses in wildlife habitat mapping. A selected bibliography is also included at the end for those wishing to obtain more detailed information on the use of satellite data in wildlife habitat mapping.

Caribou Habitat Mapping in the Southern District of Keewatin, N.W.T.: An Application Of Digital Landsat Data. D.C. Thompson, G.H. Klassen, J. Cihlar (1980)

This study was undertaken to delineate broad vegetation patterns in the southern District of Keewatin, N.W.T. covering an area of 90,000 km^2 and to determine the relative importance of broad areas as caribou habitat. The Kaminuriak caribou herd ranges throughout the southern District of Keewatin as well as northern Manitoba and northeastern Saskatchewan. The herd has a significant ecological impact on the region and so habitat utilization is very important. Classification and description in terms of vegetation cover types was accomplished initially by identifying sampling units on Landsat imagery. Cover types were selected on the basis of past vegetation studies and sampling units described in terms of the proportion of each vegetation cover type it contained. The sampling units were then clustered on the basis of having similar proportions of cover types. The relative intensity of use of each cover type by caribou was determined by the density of pellets.

Since detailed vegetation information for specific sites was not available an unsupervised classification was done on seven geometrically corrected Landsat scenes covering the area during the growing season. The pixels were clustered into eight groups and displayed on a TV monitor with each group represented by a different colour. A binary theme printout was produced at 1:1,000,000 scale of the eight classes. Units with consistent patterns of colour and texture were outlined on the classified scenes and formed the basic sampling units. Satellite colour composites and topographic maps were also consulted to avoid grouping different complexes of vegetation types. The information was then transferred to 1:250,000 topographic maps for field use. Some minor adjustements were made in the location of boundaries through an aerial reconnaissance.

Five sampling points were located within each unit but could very depending on logistical restraints. Extensive vegetation transects were then conducted to permit the description of each sampling unit by the proportions of each vegetation cover type that occurred within it. Habitat utilization by caribou was determined through winter and summer pellet group counts in each vegetation cover type by randomly located pellet transects.

In this study no attempt was made to correlate spectral classes directly with the vegetation cover types. Broad areas characterized by different patterns of vegetation were delineated to assess the importance as caribou habitat. Most cover types were represented in all units and were therefore differentiated on the basis of relative proportions within the various units. Grouping of units of similar vegetation composition was done by cluster analysis thereby simplifying the evaluation of seasonal caribou habitat. The result of the analysis indicated that six of the eight cover types were significant in discriminating among the complexes.

Analysis of pellet-group counts by cover types showed definite trends in seasonal use by caribou. By summing the products of the relative densities of pellet-groups within each cover type and the proportion of each cover type within each complex an index of the relative values as seasonal caribou habitats were produced. The caribou not only appear to select those cover types which are most preferable on a local basis but also select, on a regional basis, those vegetation complexes possessing the largest quantities of the preferred habitat types.

Satellite imagery proved useful for vegetation mapping in a tundra environment but more importantly it demonstrated the need for a digital/visual analysis approach even when only relatively broad cover categories are required.

Enumeration of Prairie Wetlands with Landsat and Aircraft Data. D.S. Gilmer, E.A. Work, J.E. Colwell, D.L. Rebel (1980)

This paper uses a double-sampling approach which first consists of making a total census of wetlands using Landsat data, and then adjusting the Landsat results on the basis of samples derived from high resolution aircraft data.

The prairie pothole region of North America covers an area of approximately 700,000 km^2 in southcentral Canada and northcentral United States. This is only 10% of the breeding range of North American ducks yet produces about 50% of the young in an average year. The abundance of water therefore determines duck productivity and size of the fall flight. Since the area is large, computer aided analysis of Landsat data was used to generate regional statistics of wetlands on distribution, size, and length of shoreline. For individual recognizable wetlands, apparent size and shoreline length were calculated. The locations were designated by a set of Universal Transverse Mercator (UTM) coordinates. The data was summarized by number, total area, and size distribution within any geographic area designated by the UTM coordinates. Medium scale (1:20,000) imagery was subsequently collected by aircraft. Since aircraft data is more costly to obtain and analyse, 1760 km of transects were flown as a sample of the whole area. Each transect was divided into segments with a total of 180 segments which became the potential aircraft sample units. Eighteen random sample units, 9.7 x 1.6 km, were analysed for the number of wetlands containing water with areas as small as 5 m across. The aircraft sample was assumed to represent an enumeration of all significant surface water within the sample frame. UTM coordinates were also recorded to enable paired comparisons with units identical in area and geographic location to Landsat-derived data. A correction factor was developed using the aircraft samples to adjust the count of surface water bodies derived from the Landsat data through linear regression analysis. The estimated number of wetlands through this method was 108% and 97% of pond numbers based on visual counts made from low-flying aircraft. This was a comparison of one estimate with another both of which may be subject to error.

The advantage to this double sampling approach is primarily the higher accuracy and secondly it could provide additional data such as wetland types and landuse practices on surrounding uplands which would increase the value of the regional assessment of waterfowl habitat.

Landsat, Wheat and Kangaroos.
G.H. Hill, G.D. Kelly (1984)

This paper examines the use of Landsat data, in both photographic and digital format, towards defining the status of grey kangaroos as grain pests in southern Queensland, Australia. The agricultural land in this region is interspersed with semi-cleared grazing areas and bordered by extensive belts of woodland and open forest. The wooded areas serve as reservoirs for cover conscious grey kangaroos. Since the winter wheat normally corresponds with a dormant stage in the native grasses, the kangaroos migrate out of the wooded habitats to take advantage of the green wheat.

Three systematic aerial reconnaissance flights (SRF) were conducted to determine kangaroo density and distribution preceeding the planting of winter grain, during the early growth stage and the pre-harvest stage. These stages were determined as the key periods for damage by kangaroos. For the SRF accurate navigation is absolutely necessary since the transects were 120 km long, spaced 4 km apart and subdivided into one minute segments. Eighteen transects were repeatedly sampled at an altitude of 76 m. The reference features plotted on the maps were rather sparce so 1:250,000 colour composite Landsat images proved ideally suited for navigation. In addition, clear differentiation between land cover types and individual paddocks made it possible to plot the position of groups of kangaroos on the imagery.

Landsat colour composites of small areas at 1:250,000 were manually interpreted for land cover types. Digital processing, supervised classification and vegetation indices were used to aid interpretation and assess accuracy. A habitat map for the whole area was produced which will provide a base for mapping the location and extent of cropped land during each survey season and therefore form the necessary facet of analyses of kangaroo usage of crops from one year to the next. To determine change between years, a subsection was taken out of the study area, and Landsat data from 1981 and 1983 resampled and registered. Principal component analysis, the first principal component from each data was combined to produce colour composite or black and white images, highlighted areas of change.

Landsat imagery was found to be an invaluable complimentary data source in regional surveys of kangaroo populations. It provided environmental inventories compatible with the scale at which aerial surveys are conducted and in a similar time frame.

Landsat-Derived Land-Cover Classifications for Locating Potential Kestrel Nesting Habitat.
J.G. Lyon (1983)

The objective of this study was to test the utility of Landsat data for Kestrel habitat assessment in Oregon. Computer-generated land-cover classifications were used as variables in a habitat rating model which rated the suitability of the study area, on a grid all basis, for Kestrel nesting areas.

A semi-supervised method was used to classify Landsat data through the use of training statistics. The accuracy of the preliminary classification was evaluated with colour infrared aerial photography and field surveys. A final classification was then done. The accuracy of the final land-cover map was evaluated through random selections of 14 quarter-section areas with two secondary sampling units in each on the aerial photos and checked on the ground. The scene classification accuracy was 93% which was due to a very good representation of the heterogeneous land-cover types. The vegetation within each land-cover types was described through fieldwork using a modified UNESCO-Fosberg classification which characterizes land cover by the dominant plant types in each stratum (Table 5).

Table 5: Description of Analysis Procedures Used in the Study of Kestrel Nesting Areas

Analysis Step	Number of Samples	Sample Unit	Purpose
A. Landsat training and digital classification	Entire study area (50,000 pixels)	Landsat pixels	Determine land-cover classes
B. Vegetation community (field) description	Subset of study area	Pixels	Determine cover of vegetation by canopy, shrub, and ground layer
C. Accuracy assessment	14 primary sample units (PSU), 28 secondary sample units (SSU)	PSU = 160 acres SSU = 9 pixels	Verify accuracy of classification of Landsat data
D. Kestrel field data collection	100 sightings	100-pixel block	Census of mated Kestrels and vegetation community description for each sighting
E. Habitat model development (model input data)	Entire study area	100-pixel block	Determine land-cover types found in Kestrel habitat
F. Verification and testing	Southern portion of study area	100-pixel grid	Training the model to discrimate nesting habitat
G. Locate potential or realized habitat	Northern portion of study area	100-pixel grid	Test the predictive capability of the model

Kestrel data was collected along a 64.3 km road circling the study area from which most interior areas could be visually scanned. Location, sex, behavior, and a description of land-cover types in a 100-pixel area around a Kestrel nest were recorded. To determine the land-cover composition of nesting areas representative areas were selected from computer-classified data and were used to develop weights in the habitat model. The location of each Kestrel pair was transferred to a line print map and the land-cover types which compose nesting areas were enumerated from the computer classification. Criteria for determining important land-cover classes for Kestrel was based on a frequency of more than 50 in the 1000 pixels that were sampled or those appearing in more than 70% of model training areas. Habitat quality was evaluated on a per unit basis in relation to the area of daily activity. Model ratings were generated for each of ten 100-pixel area of computer-classified map. To verify the model and evaluate the methodology, model ratings were used to locate an additional ten 100-pixel areas which had high model rating and which would be expected to have Kestrel nests. Landsat derived land-cover classifications were used to complete model calculations for each 100 pixel cell. Field data indicated that cells with a model rating above 20 exhibited similar land-cover composition to nesting areas.

The presence of nesting Kestrels was verified in seven of ten areas selected with model data and Kestrels were usually present in cells with model ratings above 20. In order to use the model and land-cover data, (1) model components must be quantifiable and have biological significance for the species to be studied, (2) the contribution of each submodel must represent the relative importance of each habitat characteristic for the species, (3) field data must be available to develop the weights of model components, and (4) land-cover types important to the species must be detectable from the remotely sensed data.

Remote Sensing Support for the Omani White Oryx Project. R. Harris (1983)

The White Oryx Project was established to reintroduce the White Arabian Oryx to the south Arabian peninsula. In 1980 the White Oryx were brought to Yaloomi in Omani from California and confined to a 1 km^2 enclosure to allow acclimatization to the local environment. In 1982 they were allowed out of the enclosure in order for them to become naturalized and develop a natural breeding regime.

The role of remote sensing was in the mapping of the terrain cover classes which can be associated with areas and types of vegetation. It was also used to map locational features such as roads and tracks and geomorphological features such as wadis and escarpments. Field surveys were done along transects covering the principal terrain cover types recognized in the initial mapping. The imagery was then reinterpreted and twelve terrain cover classes identified. Predominantly linear geomorphological features were also mapped. The maps produced provided environmental information about an area previously poorly mapped and which assisted in the management of the White Oryx. More specifically the maps helped in identifying the main area of suitable food plants for the Oryx; identifying main areas of shade and browse which also provide water requirements in the form of dewfall shortly before dawn; identify areas of danger to the Oryx in the form of escarpments; and identifying additional sources of plant food between sand dunes which appeared not to have moved within a period of six years. Landsat data was found to be clearly useful in mapping and monitoring this fragile desert ecosystem.

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THE USE OF MULTI-DATE IMAGERY AS AN AID TO DIFFERENTIATING CLASSES OF DECIDUOUS FOREST IN NORTHERN SASKATCHEWAN FOR MOOSE HABITAT MAPPING

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INTRODUCTION

Saskatchewan's forests occupy more than one half of the province. The northern forests fall within the boreal forest region (Rowe, 1972) which comprises the greater part of the treed areas of Canada. The Commercial Mixedwood forest zone lies within this area and occurs adjacent and north of the prairie parkland region of Saskatchewan (Figure 1). It is dominated by trembling aspen (*Populus tremuloides*) and white spruce (*Picea glauca*) in the uplands and black spruce (*Picea mariana*) and tamarack (*Larix laricina*) in the lowlands. Uplands also support paper birch (*Betula papyrifera*), balsam poplar (*Populus balsamifera*), black spruce and jack pine (*Pinus banksiana*).

The forest zone while supporting much of the logging industry in the province also provides the most productive moose (*Alces alces*) habitat. Regeneration initiated by logging and fire results in an abundance of browse for moose. Favoured browse plants include: red-ozier dogwood (*Cornus stolonifera*), cranberry (*Viburnum* sp.), Saskatoon (*Amelanchier alnifolia*), chokecherry (*Prunus virginiana*), beaked hazelnut (*Corylus cornuta*), rose (*Rosa acicularis*), alder (*Alnus crispa*), willows (*Salix* sp.) and young trembling aspen.

In an effort to provide wildlife managers with an up-to-date vegetation cover map of northern regions a pilot project was begun in 1984. Using Landsat imagery and MSS computer compatible tapes classification of the 1:250,000 NTIS Wapawekka map sheet was initiated. Although some early problems with the classification were overcome the final version was weak in the area of differentiation between different age and mixedwood classes within deciduous dominant forest. Both young regenerating stands and mature aspen stands are of interest to the wildlife manager and are important habitat for moose. White spruce is the climax species throughout the upland regions of the commercial forest and is a common understory component of mature aspen stands (Kabzems *et al*, 1976). Any method that could identify this understory component would be useful in separating the deciduous cover type into further subdivisions.

During the early stages of the forest classification of the Wapawekka map sheet visual interpretation of Landsat images indicated seasonal differences in the amount of coniferous reflectance between a summer and fall image (Forestry Workshop, 1984). This suggested that after leaf fall some of the white spruce understory may be detectable either by visual or digital analysis of multi-date Landsat imagery.

This project takes a preliminary look at the feasibility of using multi-date computer compatible MSS tapes and hardcopy output in determining seasonal differences in the location and amounts of deciduous and coniferous cover types.

METHODOLOGY

Two CCT tapes of the Wapawekka area were purchased from the Prince Albert Satellite Station; one for June 10, 1984 and the other October 8, 1984. The summer image was virtually cloud free with less than 1% cloud cover while the latter had little cloud but light haze in the northern half of the image. The study area however was confined to the extreme southwestern portion of both images. From stocks of other Landsat tapes stored at the Saskatchewan Research Council (from Saskatchewan Parks and Renewable Resources) an additional image for the 30th of April 1984 was obtained utilizing the overlap present in Landsat images at our latitude. A winter image was not available.

Common subareas were appended from the larger images through the digital program on the Aries II computer. Unsupervised classification was conducted on the raw bands 4, 5, 6, and 7. By varying the merge factors, several classifications were made of each area. The

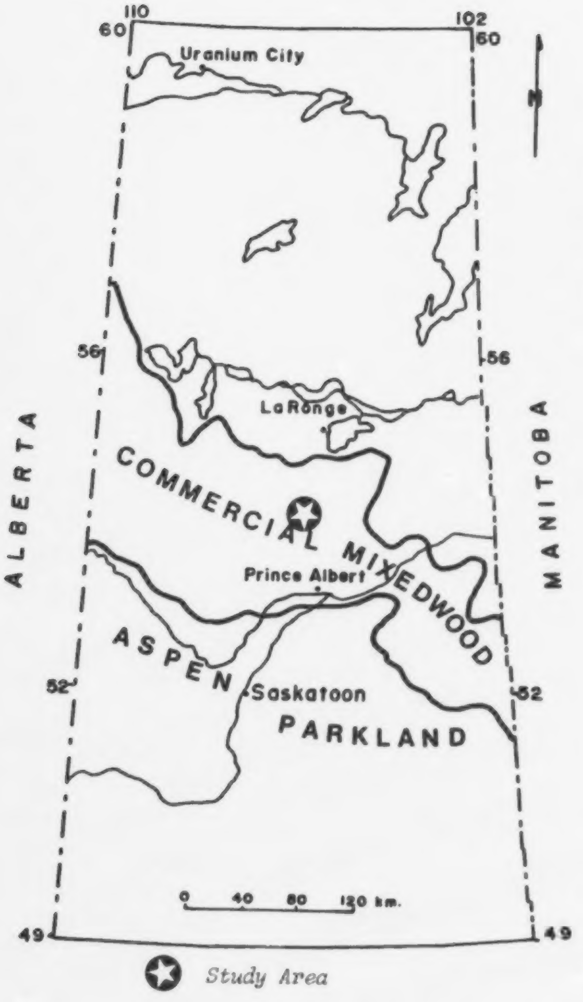
110
102
60
60
Uranium City
N
56
56
La Ronge
ALBERTA
MANITOBA
COMMERCIAL MIXEDWOOD
Prince Albert
ASPEN PARKLAND
Saskatoon
52
52
0 40 80 120 km.
49
49
Study Area

Figure 1: Location of the study area

spring image was classified using 6 and 10 classes, the summer image 9 and 11 classes and the fall 6 and 7 classes. All classifications were subjected to post filtering of 2 x 3 pixels (a minimum "eat-in" value of 2 pixels and minimum area replacement of 3 pixels). Copies of both the filtered and unfiltered versions of the classifications were printed on an ink jet plotter using both a paper and an acetate base. Acetate versions were used as overlays to compare classifications of conifers, bogs and deciduous cover in the three seasonal images. Area statistics were run on classes resulting from the unsupervised classification and area data was then lumped by habitat types. Auto correlation of distances between maximum likelihood signatures were run using 7, 9, and 10 classes in spring, summer, and fall classifications respectively.

RESULTS AND CONCLUSIONS

The number of classes possible using the unsupervised classification package on the Aries II system were 14 in the summer image, and seven in the fall.

A decimation factor of 4 had to be applied to the spring image before the number of unrecorded pixels fell below the recommended level of 10%. This indicates that reflectance values within this image were very homogenous. This appeared to be the case for both the terrestrial environment and the partially ice-covered lakes.

Summer Image - June 10, 1984

Nine classes appeared to be the best representation of cover types in the summer image. Unsupervised classification identified deciduous stands of forest when compared to the original Landsat image. One class appeared to differentiate deciduous forest which had enough coniferous component in the overstory to be classified as deciduous/coniferous mixed woods; dominated by the former. Class 8 corresponded relatively well to bog habitat but did appear to confuse bogs and coniferous forest in some areas. At least part of this confusion is attributed to the fact that bog classification ranged from open to densely treed bogs and a gradation of reflectance could be observed on the Landsat image. Lake reflectances were quite varied and accounted for 5 of the 9 classes.

Fall Image - October 8, 1984

The classes corresponding to deciduous forest appeared to compare well with the summer Landsat image. Class 2 which included bogs and conifers appeared regularly within habitat classified in the June image as deciduous. This is probably due to a conifer signature visible in the fall Landsat image. Areas classified as deciduous/conifer mixedwoods in the summer classification often appeared as conifers in the October classification.

Spring Image - April 30, 1984

Lake ice on the image appears to have added much reflectance diversity to the spring image. Originally classified using 6 classes, 5 of these pertained to the lake. Reclassification using 10 classes resulted in some separation of terrestrial environments. However, they appear to be much less accurately correlated with existing cover types. In addition there are many multi-classified pixels present in this classification.

A summary of the results of the test for auto correlation of distances between likelihood signatures are shown in Table 1. Comparisons between classes in the spring image show a relatively high auto correlation between classes labelled as conifer through visual interpretation of Landsat images. Conifers, deciduous and bog reflectances however were also correlated. This reflects the homogeneity which is apparent on the raw image.

Table 1: Auto Correlation of Signatures Developed by Unsupervised Classification of Spring, Summer and Fall Images (to at least the 50% confidence level).

	Differentiation Best		
	Spring	Summer	Fall
Conifers			x
Deciduous		x	x
Bogs	–	?	?

	Differentiated Worst		
	Spring	Summer	Fall
Conifers	x		
Deciduous	x		
Bogs	x		

Comparisons of correlations between reflectance values in classes derived from unsupervised classification of the summer image reflect the overlaps between conifer and deciduous/conifer mixedwoods and deciduous forest versus mixedwood forest. The bog classification (which includes some deciduous component) was also correlated with one of the conifer classes.

Comparisons of classes within the fall image showed a strong correlation between two of the conifer classes and a moderate correlation between the bog/conifer class and one conifer class. The reason for this later correlation is probably due to the wide range of cover types included in the bog habitat, i.e. open to densely treed bog.

Visual comparison of hardcopy classifications of June and October images did appear to provide some detection of conifers both in the aspen understory and where conifers (largely white spruce) were present in the overstory but masked by the more abundant reflectance of the trembling aspen, i.e. the dominant species.

The use of multi-date imagery as a tool to aid in forest classification appears to hold some promise but requires additional investigation. The summer and fall images were more readily classified using unsupervised classification than was the spring image. The lack of contrast between distinct reflectance classes in the terrestrial environment and partial ice cover on the lakes made accurate classification of this latter image difficult. A spring image between the April and June images may provide a better subject for classification. Although not part of this particular pilot study it should be mentioned that in order to help separate spruce (black and white spruce) and jack pine signatures, the interpreter should choose a fall image, second choice being a summer image. The spring image was less definitive. A later spring image, after conifer new growth is firmly established might also provide a suitable window for separation of the two conifer groups.

FURTHER INVESTIGATION

Ground checking of the resulting unsupervised classifications have yet to be done. The extrapolation of signature files over a larger area will also be attempted. The use of enhanced imagery (stretched) in both unsupervised and supervised classification should also be tried.

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MAPPING PRAIRIE MIGRATORY BIRD HABITAT ZONES

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ABSTRACT

In Western and Northern Region, CWS is formulating a regional approach and methodology to inventory and classify migratory bird habitats according to an ecological land classification (ELC) base. Using a map overlay system, CWS is assembling habitat units, migratory bird distribution patterns and other resource information within broad management zones. Three hierarchical levels of map units are described, based upon a standard land classification synthesized for the prairie provinces; the broadest level is the management zone or ecozone, the second level is the ecoregion, and the third level is the habitat subregion. Migratory bird sites are plotted and defined according to use by featured species groups, seasonal functions and population indices such as size, species richness and rarity. Sites are ranked as: (1) unsuitable, (2) suitable and (3) key sites. Tentatively, key sites identified from population surveys support 1% or more of a national or regional species population, or support a high species richness index. Regional comparisons of avian species distribution and abundance must account for a multiplicity of factors such as species range limits, seasonality, climatic and habitat diversity, vegetation, land use and specialized requirements. Each ELC map unit should be characterized according to habitat requisites and population parameters compatible with the appropriate level of map resolution for given species groups.

RÉSUMÉ

Le Service canadien de la faune (SCF) élabore actuellement, dans la Région de l'ouest et du nord, une approche et des méthodes applicables à l'échelle régionale pour inventorier et classer les habitats des oiseaux migrateurs selon une classification écologique du territoire (CET). Le SCF regroupe, au moyen d'un système de recouvrement cartographique, des unités d'habitat, des types de distribution des oiseaux migrateurs et d'autres données sur les ressources à l'intérieur de vastes zones de gestion. On décrit les échelons hiérarchiques des unités cartographiques d'après une classification classique du territoire obtenue par synthèse de données sur les Prairies; l'échelon le plus large est représenté par la zone de gestion dite écozone, le deuxième échelon par l'écorégion et le troisième par la sous-région de l'habitat. On reproduit graphiquement et on définit les lieux fréquentés par les oiseaux migrateurs selon leur utilisation par des groupes d'espèces caractérisées, les variations saisonnières et les indices de population comme la taille, la diversité et rareté des espèces. Les lieux ont été classés de la façon suivante: (1) habitat inapproprié, (2) habitat approprié et (3) habitats-clés. En pratique, les habitats-clés identifiés d'après des relevés démographiques abritent au moins 1 % d'une population spécifique nationale ou régionale ou présentent un indice de diversité des espèces élevé. Les comparaisons à l'échelle régionale de la distribution et de l'abondance des espèces aviaires doivent tenir compte d'une multitude de facteurs, comme l'étendue du territoire des espèces, les caractères à variation saisonnière, la diversité du climat et de l'habitat, la végétation, l'utilisation des terres et les exigences particulières. Chaque unité cartographique de la CET doit être caractérisée selon les conditions requises par l'habitat et les paramètres de population compatibles avec le niveau approprié de la résolution cartographique pour des groupes d'espèces données.

INTRODUCTION

Under its various mandates (*Migratory Birds Convention Act 1917, Canada Wildlife Act 1973 and Committee on the Status of Endangered Wildlife in Canada 1983*), the Canadian Wildlife Service (CWS) is responsible for the management of migratory birds and is involved with endangered species and their habitats. CWS also oversees the protection and management of key national habitats and plays a lead role in establishing an expanding network of National Wildlife Areas (Desmeules *et al*, 1983). To further this goal, CWS requires an inventory of key wildlife areas distributed according to natural regions in Canada.

CWS is developing a national process to set habitat management priorities and to direct habitat protection strategies for migratory birds. CWS recognizes the need to protect wildlife areas of national and international significance and to provide leadership in maintaining a system of protected areas (Staines *et al*, 1983). In order to set national and regional goals for site protection, CWS needs to inventory and monitor habitat quantity, quality, location and rates of change for wildlife. An updated assessment of the status, availability and quality of important migratory bird habitats is essential to identify key sites and to evaluate ongoing habitat loss. Inventory and monitoring contributes to national long term goals: *(1) to acquire and manage critical migratory bird habitats under extreme threat, (2) to identify and rate important wetlands in several regions of Canada and negotiate for protection, (3) to identify appropriate sites for designation of wetlands of international importance* (Ramsar Convention) (CWS 1984). Designation of key sites of national significance is facilitated through prioritizing habitats based upon regional documentation and classification of sites.

In Western and Northern Region, CWS is formulating a regional approach and methodology to inventory and classify migratory bird habitats. Using a map overlay system, CWS is assembling and consolidating habitat units, migratory bird distribution patterns and other resource information within broad management zones. Key sites of regional importance are identified for featured species from population indices, and seasonal importance values of sites. The mapping survey will assist resource planners and wildlife managers in prioritizing habitats, setting habitat protection goals, predicting disturbances to bird populations and monitoring migratory bird responses to land use changes.

RATIONALE

Migratory bird sites which fulfill for featured species a life cycle or seasonal function such as breeding, foraging or staging, are core areas delineated by high densities or concentrations of individuals, by the presence of rare species, or by zones of high species diversity. The inherent physical and biotic features of sites considered independently of the surrounding landscape and ecosystem, are usually viewed as sufficient stimuli for attracting species use. However, proximate cues to avian site selection may be based upon spatial and structural interaction of the surrounding landscape with its associated vegetation cover (Hilden 1965). Ultimate cues in site selection may relate to environmental factors such as climate, landforms and soils which are habitat independent (Balda 1975). Whereas species numbers may respond to spatial and structural habitat variables (Karr and Roth 1971, Asherin *et al*, 1979), that are measureable only at a site level, assemblages of species and distribution of sites may be portrayed at a macrohabitat scale in a spatial land unit. This assumes that avian abundance and distribution patterns can be linked to features which are ultimately related to the land unit.

The land units proposed are delineated by assembling components of soil materials, landforms, vegetation formations and plant communities, utilizing ecological land classification guidelines (Environmental Conservation Task Force 1981). Differing hierarchical levels of mapping units are necessary to portray differing habitat requirements, differing levels of species use and function, and to collate distribution information on several bird species groups. Through assessment of the land unit's characteristics, managers can often predict site sensitivity to disturbances, and functional suitability of the unit for furnishing essential life requisites for featured avian species. The ecological land unit provides an effective framework for integrating spatial and contectual environmental data with migratory bird use and function data.

CLASSIFICATION OF HABITAT ZONES

The first requirement for a regional migratory bird inventory and monitoring program is the development of a standardized land classification system for the prairie provinces. As a basis for planning and implementing the Alberta Wildlife Inventory, Pedocan (1983) laid the initial ground work by mapping habitat regions and subregions for wildlife. CWS has taken a similar approach to integrate mapped migratory bird information for the three prairie provinces. Three hierarchical mapping levels were proposed to satisfy national and regional planning needs and to collate regional characteristics and localized site data. These levels are management zones (national), regional management zones or ecoregions (regional), and habitat subregions (regional and local).

A framework of small habitat units nested within broader management zones permits stratification for sampling, monitoring and organizing migratory bird and habitat data according to ecological criteria. CWS adopted the ecological land classification approach (ELC), which uses the more stable and collective characteristics of the landscape to characterize habitat units and to emphasize -- *the functional interconnectedness of several biophysical components* (Stelfox 1982). Units are defined by the environmental synthesis method which integrates biotic and abiotic components and scales component classification levels to the preferred application level (Bailey *et al*, 1983). For example, sites are equated to ecosites, habitat units to ecodistricts or subregions, and management zones to ecoregions or ecozones.

Management Zones

Management zones defined by ecozones (Figure 1) are delineated according to major gradations in surface relief, structure or lithology, broad macroclimate, plant formations and major soil zones (Wiken 1985). Ecozones are divisions of ecoprovinces (Environmental Conservation Task Force 1981), or equivalent biotic provinces (Dasmann 1972) as differentiated by physiographic controls. Examples of ecozones include the Taiga Plains, the Boreal Plains, the Prairie, and the Montane Cordillera.

Management zones or ecozones form the broad framework for a national overview of migratory bird species ranges and for summarizing regional habitat information. Ecozone boundaries may also approximate marked continental shifts in bird species diversity as demonstrated at the northern boundaries of the taiga and the southern boundaries of the boreal forest (Kaiser *et al*, 1972). These zones provide a geographic setting for a Canada-wide perspective on regional priority assessments and habitat protection strategies.

Ecoregions

Ecoregions (Figure 1) are the second mapping level characterized by broad divisions of land integrating *macro-biota and soil indicators of latitudinal and longitudinal gradients of climatic change* (Rowe 1979). According to Environmental Conservation Task Force (1981), *ecoregions are assemblages of regional landforms characterized by distinctive ecological responses to climate as expressed by development of vegetation, soils, water and fauna.* Ecoregion components were synthesized from a combination of climatic and physiographic gradients such as elevation, broad surface materials and prevailing vegetation.

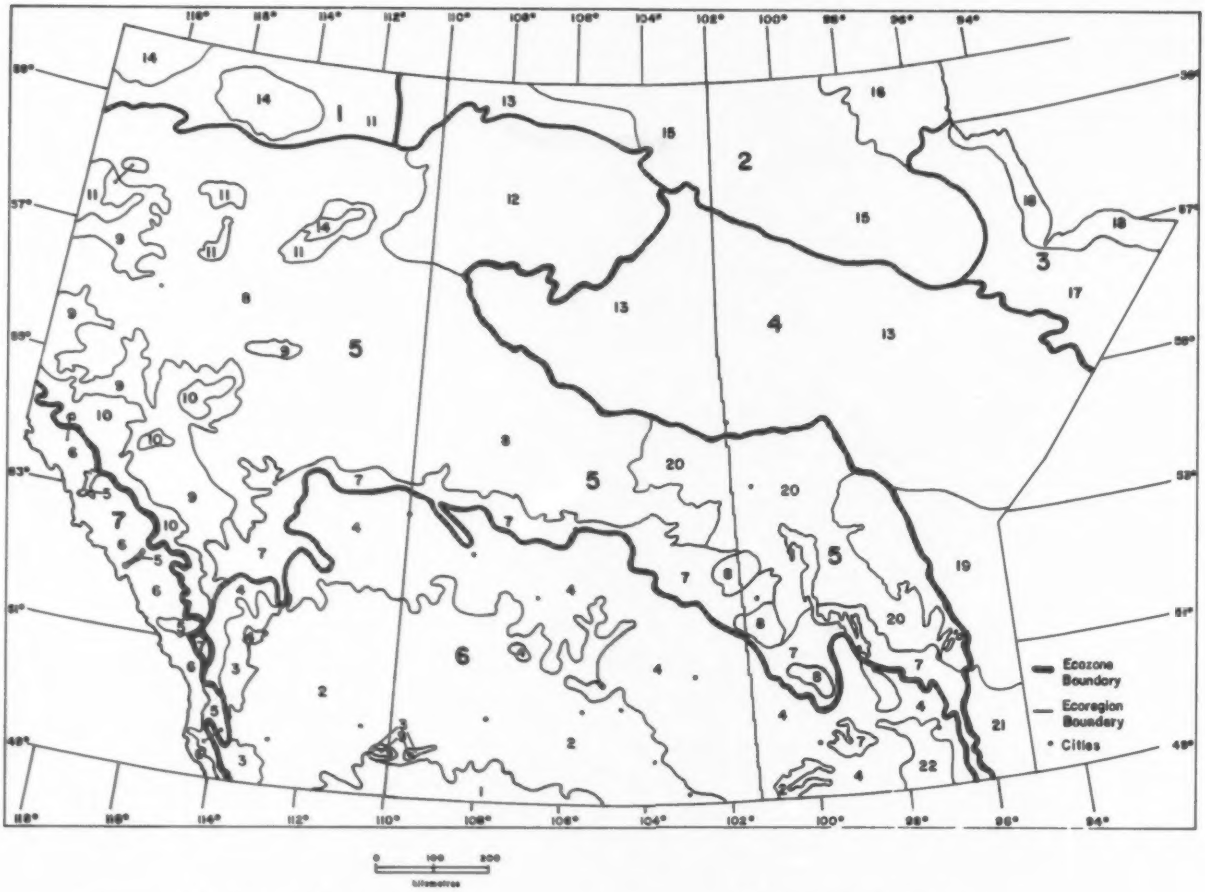
Due to incongruities in boundary-matching at provincial borders, some modifications were required in mapping ecoregions as derived from published and unpublished provincial maps (Strong and Leggat 1981, Harris *et al*, 1983, Mills 1979). Consistent linkage across the three provinces were provided by utilizing the mid-boreal transition forest boundary mapped by Zoltai (1975) and the parkland-grassland boundary mapped by Millar (1976). Adjustments in ecoregion boundaries were based upon these zones as well as common boundaries of major physiographic divisions used to integrate habitat subregions after Pedocan (1983). Examples of ecoregions include the mid-boreal mixedwoods, the parkland, and the mixed-grass prairie.

Ecoregions form the basis for regional management zones, providing a regional ecological perspective on the distribution of habitat units and implying elevational and climatic gradients which may influence avian species diversity and abundance. The ecoregions constitute the first stage of the CWS regional mapping program to integrate bird distribution patterns and key habitats.

Habitat Subregions

Delineated at the third hierarchical level, the habitat subregion is a landscape division of the ecoregion, defined by elevation, relief, regional surface form, drainage and broad genetic materials (Pedocan 1983). The subregion is similar to the physiographic section of Acton *et al*, (1960) and Pettapiece (1981), but is modified by regional vegetation zones (ecoregions).

Figure 1: Ecozones and ecoregions of the prairie provinces*



Ecozones (larger numbers)

1 - Taiga Plains
2 - Taiga Shield
3 - Hudson Plains
4 - Boreal Shield
5 - Boreal Plains
6 - Prairie
7 - Montane Cordillera

Ecoregions (smaller numbers)

1 - Short-grass Prairie
2 - Mixed-grass Prairie
3 - Fescue Prairie
4 - Parkland
5 - Montane
6 - Mountain Complex
7 - Mid-boreal Transition
8 - Mid-boreal Mixed-woods
9 - Mid-boreal Foothills
10 - Boreal Uplands
11 - High Boreal Plains
12 - High Boreal Sandplain
13 - High Boreal Precambrian
14 - Low Subarctic Uplands
15 - Low Subarctic Precambrian
16 - High Subarctic
17 - Hudson Bay Lowlands
18 - Coastal Lowland
19 - Mid-boreal Precambrian
20 - Mid-boreal Lowlands
21 - Low Boreal
22 - Tall-grass Prairie

* Compiled from: Harris et al. (1983); Millar (1976); Mills (1979); Pedocan (1983); Wiken (1985); and Zoltai (1975).

Each subregion is conceptually similar to ecodistricts (ELC) but is characterized less by homogeneity of surface materials, and more by similarities in landform, vegetation and wetland components. Examples of habitat subregions are glacio-fluvial plains, hummocky moraines and bedrock controlled plateaus.

Sources of map information for defining habitat subregions include physiographic maps for Alberta (Pettapiece 1981), Saskatchewan (Acton *et al*, 1960), and Manitoba (Mills 1980). Additional detail was provided by habitat region-subregion maps of Alberta (Pedocan 1983), a landscape map of southern Saskatchewan (Acton and Rowe 1977), soil landscape maps for Alberta, Saskatchewan and Manitoba (Shields 1982, Shields and Pettapiece 1985, Mills 1983), soil survey and geomorphology maps (Schreiner 1984).

The habitat subregion furnishes the landscape framework for integrating broad physical habitat requirements for populations of breeding and staging birds. Specialized species whose site requirements are more restricted to climatic and landform controlled features such as water bodies, valley slopes or sandhill prairie, are more likely to be representative of specific subregions.

CLASSIFICATION OF MIGRATORY BIRD SITES

Classification of migratory bird sites is contingent upon identifying and evaluating kinds of migratory bird use. Criteria for designating sites must reflect availability of survey information, the degree of detail, and the chronology of surveys. Consideration should be given to both quantitative and qualitative data acquired at varying levels of precision. Although current information is preferable, often the only available information is historic and annotative. Hence most of the designated sites reflect dated information, despite the fact that the current use of the site may have changed. One of the most important sources of breeding bird site information is the provincial bird atlas. To compensate for differences in chronology and quality of data, CWS assigned four relative confidence levels to the documentary data. These levels are:

1. High confidence data based upon surveys conducted regularly and systematically since 1975.
2. Low to medium confidence data based upon limited surveys, reconnaissance or lists made since 1975.
3. Medium to high confidence surveys contributing quantitative data obtained prior to 1975.
4. Low confidence data gathered prior to 1975 from limited surveys or annotative information.

Featured Bird Groups

Avian species may be assembled into groups according to various criteria defined by taxonomy, lifeform, guild, foraging behavior or broad habitat preferences. For integration into habitat units, species groups were defined according to ecological adaptations to broad habitat requirements, foraging behavior, and in some cases, nesting behavior. Therefore, the species groups are generally large, consisting of similar and dissimilar taxonomic assemblages such as raptors, shorebirds and perching birds. These species groups facilitate recording of flock sizes from non-specific counts (eg dabbling ducks), and are convenient to use as descriptive map symbols for designated sites. Information concerning species groups occupying sites is further modified by life cycle functions, population use indices and population status. Some key species indicative of specific sites may be identified based upon criteria such as endemic status, dominance, rarity and habitat specialization.

Seasonal Importance Factors

Sites vary in their ability to furnish essential seasonal requisites for life cycle functions, hence wildlife uses must be weighted according to duration and functional use. Seasonal factors reflect the period of maximum use benefitting the greatest numbers of individuals or species, except that priority is given to rare, threatened and endangered species (COSEWIC 1983). For common species, staging areas would normally be given preference over breeding areas due to the large numbers of migratory birds involved. Other seasonal sites designated important are colonial nesting sites or sites frequented by rare species.

Population Indices

Often the only index of site use derived from breeding bird records is presence or absence, location of nests or qualitative estimates such as rare, common or abundant. Qualitative information is of limited value for evaluating site importance, but is an indicator of use by rare or specialized species. Where census data are available, population indices provide simple, objective criteria for classifying sites. In Britain, Fuller (1980) proposed rating avian sites on the basis of three attributes: (1) population size, (2) species richness and (3) numbers of rare species. CWS adopted these three attributes and criteria relating to each are to be established for each featured bird group. A site may be designated important if it exceeds threshold levels of one or more attributes as outlined below.

Population Size - Indices of population size may be derived from quantitative estimates of species or group abundance based upon (1) a time series count of nesting individuals (Graber and Graber 1976), breeding pairs or maximum numbers staging during a season (Fuller 1980). Indirect estimates of population size are obtained from indices of average bird-days use (Williams 1980), number of songbird territories (Erskine 1977), colonial bird nest counts (Vermeer 1969), and relative flock composition. These counts are expressed as absolute numbers, bird-days, numbers per 100 ha, numbers per km of transect, or other statistics. More exact counts are obtained of large conspicuous species such as waterfowl, and from concentration areas such as colonial nesting sites and staging and moulting sites. In order to standardize these various census counts, crude densities should be calculated, expressed as average numbers per km^2 of a habitat unit (Kantrud and Stewart 1984).

Indices of population size were extrapolated from replicated surveys where available, using maximum seasonal counts or average yearly counts. The indices were qualified by confidence levels of data reliability based upon the type and replication of surveys.

Species Richness - Species richness is a component of species diversity, referring to the number of species accommodated in a community or habitat unit (alpha diversity) (Lewis 1977). Avian diversity assessed between habitats within a region is called beta diversity (Tramer 1974), which correlates with the habitat subregion level. Gamma or total diversity is equivalent to all available habitats in a large geographic area (Tramer 1974), approximating the ecoregion level. Because species richness is a function of niche space and therefore varies with the size (Margules and Usher 1981) and complexity of the community or habitat unit, the index should reflect the scale of the mapping unit. A richness or variation index is expressed usually as the number of species divided by the sum of individuals, as in Shannon's diversity index which correlates well with species richness (De Jong 1975). However, the calculation of species diversity indices is only appropriate where considerable species population data have been gathered at a community or site level. Generally a species list is adequate to explain species variability compared to a diversity index (Shugart *et al*, 1975). A simple index consists of a species list which is expressed as the proportion of recorded species observed on a site, in relation to the total available number of species occurring in the corresponding ecoregion. Available species are determined from range maps (Gollop 1981) and checklists, as modified by breeding or migratory status.

Species Rarity - Sites may be identified solely on the basis of regular use by rare, threatened or endangered species (COSEWIC 1983). These species usually exhibit common features such as small gene pools, highly localized distribution or highly specialized adaptations. According to Drury (1974) rare species occupy three general categories: (1) few individuals scattered over a large range, (2) few individuals widely dispersed within a community type, but occurring in many suitable sites, and (3) large numbers occurring in few isolated and restricted localities. Other criteria for evaluating species rarity should include population trends, endemicity, peripherality of range and habitat specialization (Adamus and Clough 1978). Species fitting the latter criteria may be of rare occurrence within an ecoregion, but may not be on the COSEWIC list. Examples of such regionally rare species include the merlin *(Falco columbarius)*, and the yellow rail *(Coturnicops noveboracensis)*.

Evaluating Site Significance

Levels of the above species attributes have to be derived and considered for allocating sites according to three categories: (1) unsuitable, (2) suitable, and (3) key sites of regional or national significance. Categorization of sites depends upon the availability of quantitative population surveys and/or annotative information about species diversity and habitat characteristics.

McCormick *et al*, (1984) define key sites as areas where any degradation or destruction could exert significant impact upon a particular population resulting in a numerical decline in numbers. They consider the relative importance of a site as a function of the proportion of the regional or national population of a species which it supports for any segment of the species annual cycle.

Tentatively, criteria for ranking significance for sites of bird concentrations such as staging areas or colonial bird nesting sites are based upon the site supporting 1% or more of the regional or national population of a species (Carp 1977, Lemieux 1982, Lloyd 1984, McCormick *et al*, 1984). For featured groups, key sites are identified as regularly supporting more than 10,000 ducks, geese or swans, more than 20,000 shorebirds, or in excess of 50,000 seabirds (Carp 1977, Lemieux 1982). Levels for other groups such as divers and waders need to be established. The 1% criterion will emphasize site importance for rare, threatened and endangered species, but sites exhibiting high species richness also need to be recognized. Tentatively, the latter sites will be identified according to seasonal occupancy by 25% or more of all migratory or resident species within the province. This level needs to be assessed from species frequency curves plotted from numerous sites.

Suitable sites are defined as sites which do not meet key site criteria, but nevertheless support on a seasonal basis, relatively high species numbers or high frequency of use by featured species. Unsurveyed sites may be ranked as suitable based upon qualitative estimates of species use or function and habitat suitability. Pending the acquisition of survey data, the latter sites may be reclassified to key sites if criteria are met. More objective limits to suitability criteria need to be set to reject those classified as unsuitable.

DISCUSSION

Efforts to relate migratory bird use to regional mapping units are hindered by a limited resource data base and a lack of knowledge of migratory bird-habitat interactions. Quantitative baseline data on migratory bird species abundance is deficient, of sporadic occurrence, and difficult to acquire. Few systematic surveys are conducted and these fail to collect the kind of information needed to relate birds to mappable habitat characteristics. Only the cooperative breeding bird surveys (Finney *et al*, 1978), some bird census plot studies (Erskine 1984), and the U.S.-Canada waterfowl breeding ground surveys provide trends on species population levels distributed over broad regions and habitat types.

Environmental and climatic factors which operate at regional levels and contribute to the designation of ecoregions, affect the continental distribution of breeding birds. These factors function as driving variables influencing habitat diversity, habitat structure and seasonal characteristics of habitats, contributing to gradients of population instability (Rotenberry 1978). Climate plays a major role expressed in latitudinal stratification as avian species richness increases from south to north on the central plains (Peterson 1975, Kantrud and Kologiski 1983). Higher species numbers are found in the southern boreal forest compared to the prairie and parkland. Kaiser *et al*, (1972) claim that latitudinal divisions reflect changes in diversity whereas longitudinal divisions separate populations of equal diversity. Continental patterns of avian diversity appear to be correlated with relative moisture availability; whereas evenness of species distribution varies with resource availability and stability as influenced by temperature regimes and post-glacial history of bird dispersion (Short 1979). Kaiser *et al*, (1972) correlated changes in diversity and homogeneity of species with temperature zones and prevailing geographic locations of major air masses. Prairie avian associations mapped by Kantrud and Kologiski (1983) generally coincide with major vegetation zones and with major soil zones such as cool-moist versus warm-dry chernozems. These studies support the rationale for relating general bird distribution patterns to ecozones and ecoregions.

Regional comparisons of avian species distribution and abundance must account for species range limits, seasonal migrations and residency status, climatic variability, size, dispersion and structural complexity of habitats, plant successional stages, land use and other specialized requirements. Each habitat subregion or smaller habitat unit should be characterized by variables reflecting suitable habitat requisites and species population parameters compatible with the appropriate scale of mapping resolution. At the subregion level only broad habitat features controlled by landforms, prevalent surface vegetation and drainage patterns are described. Corresponding levels of species use are indicated by the density and distribution of sites used by assemblages of species groups or by featured habitat specialists or rare species.

Usually bird groups rather than single species are indicative of ecosystem function or broad habitat value (Anderson 1979).

The subregion is an appropriate mapping level for integrating breeding distribution patterns for waterfowl, some endemic species and raptors, but it is an impractical scale for documenting abundance and distribution patterns for passerine birds which are strongly associated with vegetation features. Species richness of passerines varies from site to site; some species are ubiquitous with breeding ranges transcending several ecoregions. Many passerines are adapted to a variety of vegetation types and are poor indicators of landform features. Species diversity is generally linked to vegetation features such as spatial and vertical structure (Karr and Roth 1971), Asherin *et al*, 1979, Balda 1975), plant successional stage (Shugart *et al*, 1975, Margules and Usher 1981) and size of stand or community (Margules and Usher 1981, Lynch and Whigham 1984). Therefore, maps of passerine bird habitats must be capable of resolving or inferring these features from relatively small homogeneous map units. Map units incorporating these features at a plant community level are equivalent to the ecosite level of the ELC.

According to Thompson (1977) habitat units should be relatively homogeneous across landscapes and yet be specific enough to represent habitat differences which determine overall use by species. Categorization of land use and native vegetation may reflect differences in habitat suitability based upon differences in cover and resource availability. Shugart *et al*, (1975) claim that habitat dimensions are more important than food or seasonal components for influencing resource partitioning in species. A composite map relating bird distribution patterns to cover maps would display gradations in habitat suitability, assuming that relative use infers suitability (Thompson 1977). Special consideration should be given to evaluating edges of cover types as ecotones often support the highest diversity of species (Balda 1975). Cover maps should portray seral stages because avian diversity and density usually increase from early to mature successional ages in deciduous forests (Shugart *et al*, 1975). Specialized needs such as diversity of wetlands required for waterfowl, should also be depicted.

Whereas finer hierarchical mapping divisions are stressed for rating habitat suitability for featured species groups, the classification approach should be divisive proceeding from more generalized land units to more specific land units. Further divisions of landscapes or subregions may depict discrete units or associations that have a functional entity such as a floodplain habitat (Rowe 1979). Finer hierarchical divisions may be desirable to integrate all avian species, but the sheer species numbers and the complexity of map units rule against extensive ecosite mapping except on specific well documented sites such as National Wildlife Areas or monitoring sites.

Detailed classifications are impractical in terms of the geographic scope and limited resources allocated to prairie migratory bird inventories. Overall habitat evaluations should involve featured species or groups whose sites are integrated into ecodistrict or subregion units modified by overlays of vegetation and land cover maps. Avian statistics relating to species richness, distribution, abundance and rarity should be assembled and related to appropriate hierarchical mapping levels. Specific subregions which lack documented sites may be targetted for future inventories to fill information gaps. Final assessments of site and avian population data on the basis of specific ELC land units will contribute to habitat suitability ratings and prioritizing of sites for protection of migratory birds.

RECOMMENDATIONS

1. In a regional migratory bird mapping program, factors influencing avian species densities and distribution must be considered, such as species range limits, seasonal migration, residency status, as well as habitat diversity.

2. Each ELC map unit should be characterized according to variables reflecting suitable habitat requisites and population parameters compatible with appropriate scales of mapping resolution.

3. The subregion level is appropriate for integrating breeding distribution patterns for waterfowl, some endemic species and raptors. These bird groups are dependent upon landform controlled features and the distribution of water.

4. Cover maps depicting land use and native vegetation should constitute a fourth level or overlay associated with habitat subregions. Cover maps should display vegetation features such as interspersion

of cover, seral stages and ecotones which are related to avian species diversity.

5. Other specialized needs required for featured species such as wetland diversity, should be mapped or identified.

6. Composite maps should be generated relating vegetation cover -- landform features to avian distribution patterns.

7. Final habitat unit classifications should identify functional units which truly integrate avian activity with the types and areas of habitat utilized.

8. Ecosite mapping of extensive geographic areas is impractical due to the difficulty of integrating all species requirements and due to the lack of available resources.

9. The ecosite is the appropriate mapping level for integrating passerine bird habitats, but such mapping should be confined to well-documented areas such as National Wildlife Areas or monitoring sites.

10. Habitat evaluations should involve featured species requirements indicative of characteristics integrated within hierarchical ELC units.

11. More detailed inventory data concerning species richness, species distribution and abundance should be collected from ecosites representative of habitat subregions and ecoregions.

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INTEGRATING AUTOMATED LANDSAT MAPPING INTO A LARGE SCALE MOOSE CENSUS PROGRAM IN NORTHERN MANITOBA

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BACKGROUND

In September, 1982 the Manitoba Provincial Government was requested to provide moose (*Alces americana*) population information to Treaty Indian communities of the Northern Flood Agreement (NFA) area of north-central Manitoba.The 152,000 square kilometre NFA area is comprised of five Registered Trapline Districts (RTL) including: Cross Lake, Norway House, Nelson House, Split Lake and Southern Indian Lake (Map 1), each with their respective community. These RTLs are transversed by the Nelson and Churchill Rivers. Major portions of these rivers and their immediate tributaries have been affected by construction of several hydro electric dams and subsequent water impoundments. Community residents were concerned that moose numbers were declining and that the decline was attributable to hydro electric development. Treaty residents can claim compensation for such resource losses through the Northern Flood Agreement. The Manitoba Government was obligated to conduct the population survey to establish the current status of the moose population.

Responsibility for design and implementation of big game surveys lay with the Wildlife Branch of the Department of Natural Resources with funding supplied by the Manitoba Department of Northern Affairs and Manitoba Hydro.

Initial discussions with the biologists responsible for the aerial survey design indicated there was an immediate problem. The immense size of the area combined with the lack of available background information relative to local moose populations and habitat dispersion negated the implementation of conventional survey techniques. Prior stratification of habitat was required (for further information see Knudsen and Didiuk, 1985). Without this stratification standard survey techniques would be too costly and would carry excessively wide confidence levels. The recommended solution was to generate habitat maps of the entire Northern Flood Agreement area that would identify the quantity and location of winter moose habitat.

Selection of Landsat as a Mapping Base

Several factors guided the decision making process that resulted in the selection of Landsat as the most suitable mapping base. The primary criteria were:

a) the technique had to be expedient since the objective of the survey project was to conduct aerial surveys in the Southern Resource Area during the winter of 1983/84 and the other Area in the winter of 1984/85. Habitat maps for the survey area were required by December 1 of each year.

b) Funding for the mapping project was limited due to current economic constraints. Although no maximum figure was provided it was assumed that no technique requiring greater than $60,000 to $75,000 would be approved by the funding authorities.

c) The cover types that required mapping included:

    i. deciduous (tree and shrub cover)
    ii. mixed deciduous/conifer
    iii. conifer
    iv. marsh
    v. bog (including fens and muskeg)
    vi. open water

d) Colour coded habitat maps were required at scale of 1:125,000 to 1:250,000.

e) Area tabulations were required for each cover type, by mapsheet.

All possible alternative mapping bases were considered for producing the habitat maps. Available forestry inventory data and biophysical maps were considered not applicable since the cover-typing was incongruent to the mapping criteria and coverage was incomplete. Production of habitat maps from conventional aerial photography interpretation and cartographic techniques was considered too costly (new photography would be required) and would take too long to prepare. The only apparent practical alternative was to produce colour-coded thematic plots derived from computer-analysed Landsat multi-spectral digital data. A Dipix Aries II image analysis system was made available at the Manitoba Remote Sensing Centre (MRSC), on loan from the Canada Centre for Remote Sensing (CCRS). A pilot test project was initiated jointly by MRSC and the Wildlife Branch to assess applicability of the automated Landsat analysis technology to produce the desired information (for further project detail see Dixon, et al 1984). The following is a brief summary of the pilot project.

A Pilot Project to Test the Methodology

Four DICS computer-compatable tapes were chosen as a test area. This geo-corrected tape format allowed easy geographical orientation and correlated with the National Topographic Series mapsheets. Additionally, considerable time was saved by not having to geometrically correct the tapes "in house". July imagery was chosen since it represented the peak growth period for vegetation, thus providing maximum infra-red contrast between deciduous cover, conifer and bog.

Classification of the computer tapes was accomplished using unsupervised clustering and a maximum likelihood classifers(Letts, 1978). This technique utilized a minimum of ground reference data (which was not available for much of the area) and was an expedient classifier particularly since the cover types were rather general in nature.

Detailed accuracy assessments were conducted on each of the four classified tapes, then cumulated into one large data set for final accuracy evaluation. Assessments were carried out by comparing the classified image, hard copied as a thematic plot (on an Applicon Ink Jet Plotter at CCRS) at a scale of 1:150,000 to 1:56,000 scale B/W panchromatic photography. A 10% random sample of cover type areas was selected and compared using a legal subdivision (16.18 ha) as the individual sampling unit. Data was then compiled into confusion matrices and also subjected to statistical analysis.

The results are presented on Tables 1 and 2.

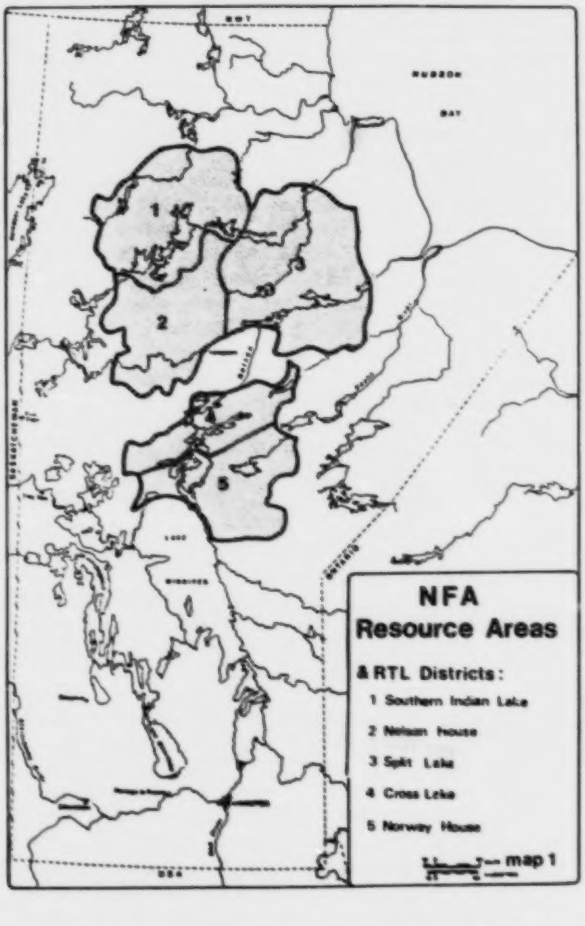

Table 1: The composite confusion matrix for all four mapsheets of data. The marsh category includes shallow water.

	Conifer	Bog	Marsh	Mixedwood	Deciduous	Water	Total
Dark Green	837	124	2	21	1	1	986
Orange	56	523	12	135	2	3	731
Yellow	0	10	80	0	0	0	90
Light Green	11	22	5	104	14	0	156
Red	0	4	0	4	47	0	55
Dark Blue	0	0	2	0	0	299	301
TOTAL	904	683	101	264	64	303	2,319

Table 2: The probability with which a colour on a thematic map will uniquely represent a vegetation type.

Colour Interval	Number of Sampling Units	Proportion Correct	95% Confidence Interval for Proportion
Dark Green (conifer)	986	0.849	0.827-0.871
Orange (bog)	731	0.715	0.683-0.748
Yellow (marsh)	90	0.889	0.824-0.954
Light Green (mixed wood)	156	0.667	0.593-0.741
Red (deciduous	55	0.855	0.761-0.948
Dark Blue (water)	303	0.993	0.984-1.000
Average Proportion Correct		0.828	

These results were reviewed by the Wildlife Branch staff involved in the design of the population survey and were considered to be an acceptable habitat data base with an acceptable level of precision.

Initiation of Operational Mapping

The DICS tapes used for the pilot test represented four of the fourteen tapes that were required to complete the mapping of the southern Resource Area, (Cross Lake and Norway House RTLs). The remaining 10 tapes were classified, areas tabulated and thematic plots produced at a 1:150,000 scale between the period of July 1 and December 1, 1983. The 1:150,000 scale provided the maximum scale format on one sheet without "decimating" the information. No further detailed accuracy assessments were performed on the last ten mapsheets. However, two days were spent flying "various" selected stands on the mapsheets and visually assessing the maps to ground cover. These observations indicated the later maps appeared consistent in accuracy to the initial four maps. A full set of Applicon-plotted maps for the southern Resource Area was then prepared and given to the biologists responsible for the aerial population surveys in late November 1983.

During the next twelve month period (December 1,1983 to December 1, 1984) the remaining 35 DICS tapes comprising the northern resource area were classified, areas tabulated and maps plotted. The same unsupervised/maximum likelihood classifers were used for all tapes. Accuracy assessment of these tapes was again not attempted since suitable photography was not available for the majority of the area.

Supplemental infra-red photography was contracted to provide support ground reference data. However the firm contracted to produce the photography mistakingly flew the contract with black and white panchromatic at infra-red aperature settings. The product was poor and provided only minimal assistance. Therefore during July of 1984 three days were spent flying various stands on twenty of the mapsheets that had been completed to that date. Observations indicated all but one mapsheet were accurate in depicting the various stands. On the one mapsheet recent burn areas were being confused as marsh. The spectral signatures of the two cover classes were too similar to allow separation, therefore the map's legend was adjusted to indicate the confusion that was present.

Integration of Landsat Data Into the Aerial Census Survey

The thematic maps and area tabulations were used in several phases of the aerial survey program. In order to better understand the integration process, a synopsis of the second winter's survey (1984/85) for the northern Resource Area is outlined (for further details see Elliott, 1985).

1. Selection of stands for aerial survey:

   In simple terms, a representative amount of the total habitat base was selected. These areas were then flown by helicopter (Bell 206) and every moose counted. The number of moose for each cover type surveyed was then totalled, averaged and extrapolated to the amount of similar habitat area in the total Northern Resource Area. The following process was followed to select the stands.

   a) A maximum theoretical amount of survey area, that is, area that can actually be flown is derived from the amount of money available and the amount of area that can be flown within a given amount of time.

   b) Only three cover types or strata were chosen for survey: conifer, mixed wood and deciduous. The allocaton of effort or amount of area to be surveyed in each strata was based upon pre-determined variance of moose in each strata and the total area of strata present. A statistical formula was then applied to yield the amount of area (km^2) within each strata that required survey (for statistical reference see Snedecor and Cochran, 1967).

   c) Each 10 kilometre grid cell on each of the 35 mapsheets was sequentially numbered. The UTM - corrected grid system had been automatically printed on the thematic maps during plot production. Numbers were then chosen from a random numbers table and the grid cells with those corresponding numbers were then visually studied. Discrete stands of the 3 strata were then selected from each cell. It was crtical to choose stands that could easily be located and isolated from aircraft to optimize the efficiency of air time. The colour thematic format of the maps greatly assisted in the selection process as the stand configuration and cover type were well portrayed. Selection of stands near geographic landmarks, such as streams, lakes or pronounced elevation changes such as eskers also assisted the selection process.

d) Once a stand was selected its approximate area was calculated using a dot grid. Areas for each strata were tallied until such time as the cumulated target area had been reached for each strata. Extra stands were selected for reasons to be explained shortly.

2. All stands (approximately 220) were then superimposed on 1:50,000 NTS mapsheets for navigational purposes. Identifying the precise location of the stands during the transfer was assisted by the UTM grid on the thematic maps. Forest fire data (post landsat image date) were also superimposed. Selected stands that had been recently burned were discarded since they were of little value as moose habitat. Additional stands were then added. Where forest fire data was not available stands were discarded "on the fly" and again replaced with alternative sites from the habitat maps.

3. All stands were also plotted on 1:250,000 NTS mapsheets to facilitate flight planning and fuel caching. Being able to identify and pre plot the stands in this manner maximized efficency of air time.

4. Once the plots were flown and moose counted, the habitat maps were then taken to the Manitoba Remote Sensing Centre where precise area tabulations were generated for each stand on a Gentian Digitizer.

5. The average number of moose per habitat strata area was then calculated and extrapolated for the total project area based on area tabulations previously generated for the mapsheets.

Results of Application and General Comments

A total of 216 stands were flown during the 1984/85 survey of the northern Resource Area. Only 3 stands were considered incorrect in cover type assignment, resulting in a 98.6% success rate.

The thematic maps were heavily utilized in the air for navigational purposes and were found to be superior to the 1:50,000 NTS maps for site-specific navigation.

Biologists using the maps recommended the maps not be filtered to eliminate "salt and pepper" effects of small stands since many of the deciduous and mixedwood stands are very small islands of habitat of 0.5 to 3.0 hectares in size. Also, one site of "salt and pepper" bog and conifer contained a large number of moose and represented a significant number of moose. Filtering would have eliminated all conifer. All three strata should therefore be left unfiltered.

After the flights it was noted that there was a general variation in the maturity of mixed wood stands east and west of the Churchill River and resulted in a mean variation in moose found in the two zones. Since the area tabulations for the mixed wood strata were available by mapsheet it was a simple matter to break the two zones apart (to the nearest mapsheet boundary) and apply a different carrying capacity coefficient to each area.

SUMMARY

A total of 22 months elapsed from initiation to the completion of the habitat mapping project. Maps and area tabulations were completed on time for use in the aerial surveys in the five RTL's. Approximately 1.25 staff years were required to conduct the exercise with a total project cost, excluding staff time of $42,000. It is important to point out that there were no computer use charges levied by MRSC.

It is not practical to estimate for this report a total cost of production of similar habitat maps by conventional aerial photograph interpretation and cartographic techniques. However it is estimated that it would cost between $100,000 to $150,000 alone to procure new black and white photography for the entire N.F.A. area (pers. comm. C. Elliott, April 1985).

The total cost of the habitat mapping and aerial survey projects for the 152,000 km2 N.F.A. area was $220,000. Staff involved in the survey design estimate the total cost of the projects represents a 50%-75% savings over conventional survey techniques that would have been utilized based on no prior habitat stratification (pers. comm. B. Knudsen, May 1985). The savings is equivalent to the approximate cost of the image analysis system used in the mapping exercise.

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SIDEC — UNE BANQUE DE DONNÉES ÉCOLOGIQUES GÉOCODÉES FONCTIONNELLE À HYDRO-QUÉBEC

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RÉSUMÉ

SIDEC (Système intégré des données écologiques de la Côte-Nord) est une banque géocodée de données qui a été mise sur pied en 1979 pour répondre aux besoins créés par l'inventaire écologique de la Côte-Nord. Cet inventaire, réalisé selon les normes de l'Inventaire des terres du Canada, a couvert un territoire d'une superficie de 200 000 km^2. Les données générées sont les contours de quelque 55 000 cellules, réparties sur 65 feuillets cartographiques à l'échelle du 1:125 000. Celles-ci constituent les données de base, soit les données du niveau I. Les données du deuxième niveau sont fournies par la suite et constituent essentiellement des regroupements de cellules; ce sont les écorégions et écodistricts. Les données du troisième niveau sont générées par le système lui-même et constituent sa principale raison d'être. Elles se résument par le calcul d'une classe attribuée à chaque cellule. Celle-ci est calculée par le moyen d'une clé d'interprétation utilisant les données stockées.

Le caractère manuscrit des données écologiques composées de 13 500 fiches descriptives d'écosection comportant chacune quelque 35 descripteurs alphanumériques de format variable a posé certains problèmes. L'entrée de données en format libre a été effectuée directement à partir des fiches descriptives d'écosection et un programme de validation suivant la méthode de l'analyse syntactique a été développé. La digitalisation des coordonnées spatiales des écosections a été accomplie en utilisant la méthode de gravure de contour et de lecture optique. Ensuite, une phase de compression et de ré-alignement des données spatiales ainsi que de re-codification des données écologiques a été entreprise. Des programmes de traçage et de remplissage de surfaces ont été développés pour produire des cartes interprétées reproductibles. Le produit final est obtenu par procédé photomécanique en utilisant les cartes tracées par le système SIDEC directement pour le tirage des négatifs et l'impression couleur sur acétate. L'informatisation de l'inventaire écologique de la Côte-Nord a permis une réduction des coûts de production de cartes thématiques de l'ordre de 15 à 20 fois en plus d'augmenter considérablement l'accès aux données de cet inventaire.

ABSTRACT

SIDEC (Système intègre des données écologiques de la Côte-Nord) is a geocoded information system created in 1979 as a processor of the St-Lawrence North Shore ecological survey. The survey, undertaken and completed in concordance with the Canada Land Inventory guidelines, covered a 200 000 km^2 area. Generated information consisted of the spatial coordinates and ecological description of some 55 000 cells dispersed within 65 maps at a scale of 1:125 000. This formed the basis of SIDEC and was defined as the first level of information. The second level of information is the grouping of these cells within ecoregions and ecodistricts. SIDEC generates the third level of information, which is essentially a capability class attributed to each cell; this is done by means of an interpretation key based on the other two levels of information.

Certain problems arose during the treatment of the handwritten ecological information comprised of some 13 500 field data sheets, each containing 35 alphanumeric descriptors in variable format. Free format input was used and a validation program based on syntactical analysis was developed. The spatial coordinates of the cells were digitized using a scribing and optical scanning method. Next, a phase of data compression and realignment of the spatial coordinates as well as a re-codification of the ecological data was undertaken. Mapping and area-fill programs were developed for the production of interpreted and reproducible maps. The final product is obtained by photo-mechanical process using the maps generated by SIDEC for direct production of negatives and color acetates. The development and operation of SIDEC has achieved a reduction in production costs of thematic maps to the order of 15 to 20 times and has considerably increased ease of access to the St-Lawrence North Shore Survey.

INTRODUCTION

SIDEC (Système intégré des données écologiques de la Côte-Nord) est une banque géocodée d'information qui a été mise sur pied en 1979 pour répondre aux besoins créés par l'inventaire écologique de la Côte-Nord. En effet, l'expérience acquise lors de l'utilisation des données de l'inventaire écologique de la baie James avait démontré la complexité et les coûts importants liés à l'utilisation des résultats de ce type d'inventaire. Nous allons donc d'abord décrire les principales caractéristiques de ce type d'inventaire, les besoins qu'il crée en termes d'utilisation et enfin, présenter les moyens informatiques utilisés pour répondre aux besoins. Nous terminerons par un bref regard sur les coûts de développement et d'opération et les développements futurs.

L'INVENTAIRE ÉCOLOGIQUE

L'inventaire écologique intégré est une méthode d'inventaire du territoire relativement nouvelle qui vise à éviter les cartographies multiples et sectorielles dont les résultats sont toujours difficiles à intégrer. C'est-à-dire qu'il s'agit d'éviter d'obtenir autant de cartographies différentes qu'il y a de spécialités, d'autant plus que la simple superposition de cartes thématiques différentes ne suffit généralement pas à dégager les relations recherchées entre les variables.

Ce qui est proposé par l'école australienne (Christian et Stewart, 1968), méthode par la suite adoptée au Canada, est de reconnaître des surfaces jugées homogènes et où la relation entre les variables est déjà connue. Puisque la méthode a été conçue essentiellement pour l'inventaire de grands territoires, le travail se fait sur photographies aériennes à l'échelle relativement petite, généralement 1:60 000 sur lesquelles on reconnaît des "landforms". Pour chacun, on assume une séquence de textures et de drainages. Ce sont des "patterns" de "landforms" que l'on cartographie à l'échelle du 1:125 000. Les autres variables sont considérées comme dépendantes de celles-ci, sauf le climat régional qui est reconnu en recherchant les variations dans les chronoséquences végétales pour un même type de surface.

L'échantillonnage du terrain vise (1°) - à élaborer les clés de photo-interprétation pour reconnaître les types de surface et (2°) - à déterminer les différents stades de végétation caractéristiques de chacun. On obtient ainsi l'information de base ou de premier niveau. Par la suite, un traitement de cette information est effectué par l'équipe d'inventaire en vue de détecter le climat régional et ainsi de définir les écorégions ("régions écologiques") et les chronoséquences pertinentes à chaque région. Les écodistricts ("districts écologiques") sont des regroupements d'unités basés sur le relief et les dépôts. Cette information générée à partir de la première, l'organise en vue d'une utilisation ultérieure et constitue l'information du deuxième niveau.

Le troisième niveau est celui de l'utilisateur, donc celui qui nous concerne plus particulièrement. Il s'agit, pour l'utilisateur, de générer, à partir de l'information de base, les cartes thématiques qui l'intéressent. Ceci se fait généralement en élaborant une clé de potentiel combinant d'une façon plus ou moins sophistiquée les états d'un certain nombre de variables retenues. L'élaboration de la clé peut aussi utiliser l'information provenant d'autres inventaires, fauniques par exemple. Le tableau 1 est une liste non-exhaustive des clés réalisables à l'aide de cette méthode d'inventaire.

La fiche d'écosection ("système écologique") contient des informations manuscrites définissant de façon détaillée la surface délimitée par une ligne pleine ainsi que les surfaces des "sous-systèmes aquatiques" délimitées par une ligne pointillée.

Chacune des écosections cartographiées sur le territoire possède une fiche d'écosection unique, mais la correspondance entre fiche et écosection cartographiée ne peut se faire que par analyse visuelle puisque dans bien des cas, on peut trouver plusieurs écosections identiques en définition, où la seule différence est l'emplacement spatial.

DÉVELOPPEMENT INFORMATIQUE

Pour bien identifier chaque fiche à son écosection, nous avons intégré un système de numérotage où, à chaque écosection, est assigné un numéro séquentiel unique et où, à chaque "sous-écosection aquatique", est assignée un numéro séquentiel de "sous-écosection". Ainsi, nous arrivons à identifier sans ambiguïté chacune des écosections cartographiées. Le processus de numérotage consiste à retrouver, via une analyse visuelle, la fiche correspondante à l'écosection numérotée. Une fois repérés, les numéros d'écosection et de sous-écosection sont ajoutés directement sur la fiche d'écosection.

Tableau 1: Nature des interprétations possibles pour l'aménagement du territoire à l'aide de l'inventaire écologique (tiré de Jurdant et al, 1977).

Agriculture
- Aptitude des sols pour l'agriculture
- Aptitude des sols pour diverses cultures
- Risque d'érosion du sol
- Identification des problèmes d'aménagement

Forêt
- Aptitude des sols pour la production de matière ligneuse
- Aptitude des sols pour diverses espèces ligneuses
- Difficulté de plantation
- Coût de reboisement
- Coût de production des plantations
- Potentiel de régénération naturelle
- Espèces agressives après coupe à blanc
- Espèces agressives après feu
- Risque de chablis
- Traficabilité

Récréation
- Attrait du paysage
- Potentiel récréatif des lacs et rivières
- Aptitude pour la récréation dans la nature
- Possibilité pour terrain de camping
- Possibilité pour lac artificiel
- Possibilité pour sentier, infrastructure, etc.
- Possibilité pour centre de ski
- Possibilité de reboisement esthétique

Faune
- Aptitude pour la faune terrestre
- Aptitude pour la sauvagine
- Aptitude pour la faune aquatique
- Production potentielle de plantes utiles à la faune

Eau
- Capacité de rétention en eau des sols
- Qualité de l'eau

Ingénierie
- Potentiel pour diverses activités relevant de l'ingénierie

Zones Écologiquement Sensibles
- Délimitation des zones

Une fois le numérotage d'une carte écologique terminé, les fiches descriptives d'écosection sont vérifiées pour repérer des caractères illisibles qui sont corrigés, permettant ainsi une réduction des erreurs de lecture lors de la perforation des données.

La perforation des données se fait directement à partir de la fiche manuscrite en format libre où le seul champ fixe est le numéro d'écosection. Étant donné le caractère hautement variable d'une fiche écologique, les directives de perforation ne prévoient aucun champ de longueur fixe. Au contraire, la fiche est divisée en plusieurs blocs d'information, chacun se terminant par un point. Si le bloc d'information est vacant sur la fiche, il n'y aura qu'un point de perforé. Chacun des blocs d'information peut aussi contenir plusieurs sous-blocs d'information, chacun séparé par une virgule. Si le bloc d'information est vacant sur la fiche, il n'y aura qu'un point de perforé. Le produit de la perforation est un nombre variable d'enregistrements pour chaque fiche écologique à valider.

Le programme de validation écrit en PASCAL se base sur une méthode d'analyse syntactique où la position logique d'une information prime sur sa position physique. A chaque fois que la position logique d'une information ne correspond pas aux conditions programmées, un message d'erreur est généré et le programme ne se préoccupe plus de valider les enregistrements de cette fiche en particulier. Aussi, la validation se fait par passe jusqu'à l'élimination de l'ensemble des erreurs.

Le deuxième sous-ensemble de SIDEC concerne les informations spatiales de la cartographie écologique, soit les limites géographiques des écosections cartographiées au 1:125 000 qui doivent être digitalisées et mises en relation avec les données alphanumériques.

Une copie vermillon à la ligne blanche est prise de la carte écologique par procédé photomécanique, copie qui fait ressortir toutes les informations cartographiques en blanc sur un fond de couleur orange. Ensuite, les contours des écosections et de leurs "sous-écosections" sont gravés avec un instrument pointu pour enlever la couche blanche et rendre les contours transparents.

Après vérification que l'ensemble des contours ont bel et bien été gravés, la carte finalisée est positionnée sur un lecteur photo-électrique à tambour. Le processus de digitalisation fonctionne par réflexion. Si un contour a été gravé, alors la lumière émise par le faisceau traverse la carte et il y a réflexion. Chaque point d'une carte est donc allumé ou éteint. Le produit de la digitalisation est une matrice binaire qui est ensuite transformée par le truchement d'un logiciel de conversion matricielle en un fichier de segments, un segment étant l'ensemble des coordonnées (UTM) par laquelle passe une ligne entre deux points d'intersection. Ce fichier nous est transmis avec un fichier de correspondance contenant essentiellement les numéros de "sous-écosections aquatiques" et leurs numéros correspondants de segments.

SIDEC étant un système basé sur des informations spatiales comparativement à des systèmes à information linéaire ou ponctuelle, les segments appartenant à un "sous-écosection aquatique" doivent être repérés et ordonnés pour constituer le contour total d'un polygone. De plus, les coordonnées d'un contour doivent être comprimées pour limiter au strict nécessaire le nombre de points à traiter. La reconstitution d'un polygone est accomplie en trouvant chacun des segments appartenant à un polygone et en déterminant leur séquence physique.

La compression des coordonnées vise deux buts. Premièrement, une réduction en nombre des points en ne conservant qu'une coordonnée au 50 m^2. Ceci nous donne une précision physique de quelque 200 points au pouce. Nous croyons que cet ordre de précision opérationnelle est le mieux adapté aux limites, premièrement de la technologie d'impression matricielle et deuxièmement, de l'acuité visuelle. Le deuxième but est de réduire l'espace nécessaire pour l'entreposage d'un polygone en gardant la première paire de coordonnées en valeurs absolues, tandis que les autres coordonnées du polygone sont transformées en valeurs relatives où chaque point peut prendre l'une des huit directions en fonction du point précédent.

Ces deux opérations permettent une réduction de l'ordre de six de l'espace utilisé pour entreposer ces polygones en comparaison avec les polygones avant traitement, composés d'un nombre de coordonnées en valeurs absolues.

De plus, le ré-alignement des coordonnées aux 50 m^2 permet une compatibilité absolue avec le format DIPIX des images LANDSAT et nous offre de façon plus pragmatique l'utilisation éventuelle des informations issues d'un traitement numérique des images LANDSAT.

Les données alphanumériques des écosections sont ensuite recodifiées en valeurs numériques et entreposées dans une structure relationnelle de banques de données. Le concept relationnel a été retenu parce que les blocs d'information apparaissant sur la fiche descriptive d'écosection ne sont pas nécessairement accédés à chaque analyse des données, en plus de bien se prêter à une structure rectangulaire de sous-ensembles.

Des spécialistes concernés développent des clés d'interprétation des données écologiques du système SIDEC qui sont ensuite programmées. Une fois appliqués aux données écologiques, ces programmes obtiennent une pondération ou classe de potentiel pour chacun des polygones du système.

La carte ainsi pondérée est tracée autant de fois qu'il y a de classes de potentiel, chacune des sorties contenant uniquement les polygones complètement noircis et appartenant à une même classe. Dans le cas de la clé de potentiel pour l'habitat de l'orignal qui assigne un maximum de cinq classes aux écosections, cinq sorties complémentaires sont produites par le logiciel de traçage. Ces cartes tracées constituent le matériel de base et le produit final du système SIDEC. Le tirage de négatifs et l'impression par procédé photomécanique sont accomplis directement à partir de ce produit.

La production traditionnelle des cartes de potentiel à partir des informations écologiques de l'inventaire de la Basse Côte-Nord était accomplie par du personnel qui appliquait directement la clé d'interprétation à la fiche descriptive d'écosection. Une fois le polygone classifié, sa surface était coloriée à la main. Le produit final était ensuite obtenu par procédé photomécanique. Dépendant de la complexité de la clé d'interprétation, ce travail nécessitait entre deux et quatre jours par carte au 1:125 000. En tenant compte de l'ensemble du territoire à interpréter, le coût minimal par production traditionnelle était de 30 000 $ par clé d'interprétation. Ce coût élevé contribuait à l'inaccessibilité de l'inventaire.

Le coût total de développement et de mise en opération du système SIDEC est de 215 000 $, l'équivalent de la production manuelle de sept clés d'interprétation de l'inventaire écologique et 8% du coût total de l'inventaire. Compte tenu du caractère quasi permanent de l'inventaire écologique de la Basse Côte-Nord, nous estimons qu'à long terme, quelque 100 clés d'interprétation seront développées. Présentement, 12 clés d'interprétation ont déjà été développées et intégrées au système SIDEC.

CONCLUSION

Le coût minimal de cartographie automatique pour une clé d'interprétation sur l'ensemble du territoire en question est de 2 000 $. Ceci signifie une réduction des coûts de production de la cartographie thématique de l'ordre de 15 fois en plus d'augmenter considérablement l'accès aux données de cet inventaire et de réduire le temps nécessaire pour mener à terme une étude thématique.

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Tableau 2:

Produit	Coût ($)	
	Total	Par carte
a) Développement		
. Inventaire de la Basse Côte-Nord	2 500 000	38 461
. SIDEC		
- Ressources humaines	121 425	1 868
- Digitalisation des contours	22 750	350
- Perforation des données	10 125	155
- Frais d'ordinateur	60 000	923
Total (SIDEC)	214 300	3 296
b) Production		
. Production thématique manuelle	30 000	462
. SIDEC		
- Programmation d'une clé d'interprétation	660	10
- Exécution de la clé	335	5
- Traçage des cartes thématiques	1 005	15
Total (SIDEC)	2 000	30

AN APPROACH TO IDENTIFICATION OF KEY TERRESTRIAL HABITAT SITES IN NORTHWEST TERRITORIES

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ABSTRACT

The Canadian Wildlife Service has recently completed a catalogue of key migratory bird terrestrial habitat sites in Northwest Territories. Administrative and biological considerations and guiding principles are discussed in addition to the method of identifying these sites. Sites which support at least one percent of a national population (species or subspecies), for any portion of the year, are recognized as key habitat sites. Advantages and disadvantages of this approach are also considered. A total of sixty one key habitat sites were identified.

INTRODUCTION

"The habitat of an organism is, simply, the place where it lives. It is the physical area inhabited by an organism and, on a larger scale, by the species"(Moen 1973). Habitat constitutes the essential materials (food, cover, and protection) which are necessary for growth and reproduction of a species. Adequate habitat (both quantity and quality) therefore, is fundamental to the welfare of a population or species. Not suprisingly, considerable effort has been devoted to the identification of key habitat sites and the literature abounds in proposed methods (Margules and Usher 1981). In this paper, "key" refers to "high biological value". It may be considered equivalent to "critical","important" or any other term which is used to describe the same concept (Donihee and Gray 1982).

The Canadian Wildlife Service (CWS) has recently completed a compilation of the key migratory bird terrestrial habitat sites in Northwest Territories (N.W.T.)(McCormick et al. 1984). The identification of key habitat sites involves both biological and administrative considerations. The purpose of this paper is to : 1)discuss some of the factors and assumptions which were considered, 2) outline the approach to identifying key habitat sites, and 3) consider some of the advantages and disadvantages of this method.

RÉSUMÉ

Le Service canadien de la faune a récemment terminé la rédaction d'un catalogue sur les habitats-clés terrestres des oiseaux migrateurs dans les Territoires du Nord-Ouest. On examine des questions et des principes directeurs d'ordre administratif et biologique, ainsi que la méthode permettant d'identifier ces habitats. Ceux qui abritent au moins un pour cent d'une population nationale (espèce et sous-espèce), à tout moment de l'année, sont considérées comme des habitats-clés (61 habitats-clés ont été identifiés au total). On examine également les avantages et les inconvénients de cette approche.

ADMINISTRATIVE CONSIDERATIONS

Mandate

Under the Migratory Birds Convention Act (MBCA), the CWS is responsible for managing populations of migratory birds which occur within Canada. Pursuant to this Act, the CWS administers the Migratory Bird Regulations addressing the harvest and possession of migratory birds and the Migratory Bird Sanctuary Regulations providing for the establishment and management of bird sanctuaries. In addition, the CWS also administers the Canada Wildlife Act. Under this legislation, the CWS may take measures necessary for the protection of any species of non-domesticated animal in danger of extinction or acquire lands for the purpose of wildlife research, conservation, or interpretation. The administration and management of such lands is governed by the Wildlife Area Regulations.

As clearly indicated in the MBCA, the primary responsibility of the CWS is to maintain or enhance the population levels of migratory bird species. Accordingly, the maintenance of migratory bird populations is the primary purpose of protecting key habitat sites.

Scope

The CWS is committed to the conservation of all species and subspecies of wildlife within N.W.T. However, the GNWT Department of Renewable Resources is responsible for managing mammals and certain species of birds. Therefore, only migratory birds, as defined under the MBCA, were considered. As a federal agency, the CWS manages migratory birds within a national perspective. Potential key habitat sites were considered in a similar context.

Audience

The catalogue of key habitat sites is a public document. Although it will be used for CWS program planning, it was primarily intended as a statement; to the public, other government departments, and development companies; of CWS interest in various key habitat sites.

BIOLOGICAL CONSIDERATIONS

Populations are functional wildlife management units. Like the establishment of hunting seasons and harvest limits, the protection of key habitat sites is a population management tool. However, the effectiveness of habitat site protection as a population management tool is dependent upon a species' biology. The following general statements can be made;

1) Populations which are geographically dispersed or select a wide variety of habitats are less vulnerable to site-specific threats as only a small portion would be affected. For these species, it is impractical to control and manage enough habitat to support a significant portion of the population.

2) Populations which are concentrated, for any part of the year, are potentially vulnerable to site-specific threats because a significant portion of the population could be affected. Such habitat sites include staging areas, moulting areas, nesting colonies, and the foraging areas of some species.

3) Populations that occupy habitats of restricted geographical area are vulnerable if their habitat is threatened. Certain rare or endangered species are prime examples.

With regard to the last two categories, certain sites are so important that their degradation or destruction could have a significant negative impact upon a particular population. The severity of a perceived threat is evaluated in terms of the numerical decline of a population. Accordingly, the importance of a particular site is a function of the portion of a population which it supports.

PRINCIPLES

In light of the above considerations, a number of principles were identified to guide the development of an appropriate habitat evaluation system.

1) All species have equal status under the MBCA. Traditionally, management efforts have been concentrated on game species such as geese and waterfowl. For this exercise, all species were considered to be of equal biological value regardless of their economic importance.

2) The system should be simple. The need for subjective evaluation was reduced by using the minimum number of criteria which would produce a realistic ranking of sites. The inherent limitations of subjective criteria are obvious.

3) The system should be universal. Despite the diversity of climatic conditions, habitat types, and land use patterns, the criteria had to apply consistently throughout N.W.T. if the system was to be an effective planning mechanism.

4) The system must have a sound biological basis. Due recognition was given to both the reasons for key habitat site protection and the scope of its effectiveness (see above).

5) Evaluation criteria should be based on quantitative data, wherever possible. Although some judgements may not be amenable to quantification, subjective criteria were often hard to interpret and harder to defend. Quantitative criteria require essentially a "yes/no" response.

THE APPROACH

A minimum requirement was established, as a guideline, for the recognition of a key habitat site. Sites which support at least one percent of a national population (species or supspecies), for any portion of the year were considered to be key habitat sites. This criterion is not without precedence (Atkinson-Willes 1976, Prater 1976, Fuller 1980). It represents a compromise between recognizing a biologically significant portion of a population and the need to avoid identifying the entire geographical range of a species as key habitat.

A total of 15 migratory bird species were identified that met the appropriate biological criteria (see above). This total included six seabird species (breeding colonies), seven waterfowl species (breeding, moulting, and staging sites) and five rare, threatened, or endangered species (breeding sites). (Some species are included in more than one group).

Canadian and NWT (where possible) population estimates were determined for all of the above species. For most species, the total Canadian breeding population is confined to the NWT. Canada geese presented a problem. Various populations (Short-grass Prairie, Rocky Mountain, Tall-grass Prairie) are composed of more than one subspecies. In this case we considered the numerical status of these populations rather than that of the various subspecies.

The number of individuals, of each species or subspecies, observed at potential key habitat sites was then determined. Sites which supported at least one percent of the Canadian population, for any portion of the year, were identified as key habitat sites. A total of 61 sites were identified.

LIMITATIONS OF THE APPROACH

Data

We have relied upon the best available estimates of national and NWT populations and the numbers present at each site. In some cases the available information is dated or limited to a single visitation. Although such data are hardly ideal, they do provide an initial identification of sites and an indication of where further information is needed.

Actual *vs* Potential Habitat

It has been argued that this approach ignores habitat sites which could be occupied in the future. It should be emphasized that CWS protects and manages populations. We must, therefore, focus on the sites where populations are presently concentrated. Sites will be added to or deleted from the list as additional field work is completed.

ADVANTAGES OF THE APPROACH

Simplicity

The system is simple. Only one subjective decision (minimum population level) is required. The audience has little difficulty in understanding how sites were chosen or the reason for their selection.

Equality of Sites

The value of a site is directly related to the portion of a population which it supports, regardless of absolute numbers. For example, 2% of the eastern Arctic population of lesser snow geese is approximately 20,000 birds whereas 2% of the Canadian population of ivory gulls is approximately 50 birds. This "common denominator" (% of a population) can be consistently applied across the geographical area in question.

Intrepretation

Absolute numbers are meaningless if they are not put in a proper context. The public can more readily accept our choice of a site when it is justified in terms of its importance to a particular population or species.

Ranking

Occasions (program planning, proposed designation, etc.) often arise when comparisions or choices must be made between sites. In light of the considerations above (equality of species), the sites are easily ranked on the basis of the portion of the population which each site supports. A subjective decision may be necessary in the case of two sites with equal rank. The ranking however, could be further refined on the basis of the CWS's national and international commitments. For example, a site supporting 25% of an international population (ie: North American) would rank higher than a site supporting an equal portion of a national population.

SUMMARY

The recognition of key habitat sites must be a dynamic, iterative process. The importance of individual sites will fluctuate in response to their utilization by various populations. Site importance will be re-evaluated as further information becomes available.

The above system provides the CWS with a simple, straight-forward means of determining our program priorities and relaying this information to the public and other interested parties.

ACKNOWLEDGEMENTS

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THE NORTHERN ENVIRONMENT INFORMATION MANUAL

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ABSTRACT

In 1983, the Lands Directorate of Environment Canada initiated a project to improve the incorporation of environmental considerations into oil and gas development decisions. This paper describes the evolution of the project to the present "Northern Environment Information Manual" format, its potential users, and a prototype undertaken to test the feasibility and effectiveness of the Manual design.

RÉSUMÉ

En 1983, la Direction générale des terres a commencé un projet servant à améliorer l'incorporation des aspects environnementaux dans les décisions touchant au développement des hydrocarbones. Cet article décrit l'évolution de ce projet, jusqu'à son présent format, c'est-à-dire le "Northern Environment Information Manual", ses utilisations potentiels, ainsi qu'un prototype développé afin de tester la possibilité et l'efficacité du format du manuel.

BACKGROUND

The Environmental Conservation Service of Environment Canada together with resource agencies of the territorial governments have made a major contribution to baseline data collection for Northern Canada over the last two decades. In the initial phase of investigating the nature, distribution and abundance of natural resources, emphasis has been placed on data compilation rather than the interpretation of this data for environmental assessment and management purposes. However, pressures for northern hydrocarbon production currently demand that greater attention be focussed on the meaning or implications of this baseline data to development decisions.

The Lands Directorate initiated an Environmental Guidelines Project under the Northern Oil and Gas Action Program (NOGAP) to improve the incorporation of environmental considerations into the land allocation decision process. The objective was to develop area-specific environmental guidelines to highlight geographic areas of key environmental value in principal regions of northern oil and gas interest and provide recommendations as to means to ensure the conservation of these values (Wiken and Ironside, 1984). The first year was spent establishing a format for environmental guidelines which is both feasible, from the perspective of the data gatherers and analysts, and valuable to those charged with making equitable decisions about land, within restricted time frames.

Extensive consultations with key personnel involved in environmental conservation and land/water use regulation were conducted throughout the year, culminating in a workshop held in Edmonton in March 1985. The "Workshop on Environmental Guidelines for Northern Hydrocarbon Development Decisions" achieved a consensus on the best format for the guidelines, based on detailed profiles of those decisions requiring environmental input, and consideration of a range of approaches which have been used in other regions across Canada. The term "guidelines" was replaced with "Northern Environment Information Manual", to more accurately reflect the nature of the recommended format. The Workshop also urged the Lands Directorate to continue to coordinate the compilation of a prototype Manual by government resource agencies, to test the feasibility and effectiveness of the recommended format. This prototype was completed over the summer of 1985.

This paper describes the major decision points and user groups for which the Manual is designed, the components of it, and the results of the prototype preparation. The paper is intended to generate further discussions and recommendations regarding the structure of the Manual.

USERS AND DECISION POINTS

The Northern Environment Information Manual is designed to assist the project planning and approval process, and is aimed at petroleum industry development proponents and government agencies with advisory or regulatory authority in the areas of land use and environmental protection. It is geared to the technical/operational level in those areas.

Although the requirements of these users are the foremost concern, the Manual will be more widely applicable, for two reasons. First, the format requires an interpretation rooted in the nature of the resources, rather than in the nature of development. Second, the "resource" interpretations to be included (e.g. fish and wildlife habitat, hydrologic features, areas of socio-cultural interest, terrain sensitivity, historic and archeologic sites) are factors which should be considered in a wide range of project-specific evaluations and planning exercises.

As such, typical types of decisions or transactions which may benefit from use of the Manual include:

- Project planning by petroleum industry development proponents;
- Issuance of Land Use Permits by Department of Indian and Northern Affairs (DIAND);
- Negotiations for Oil and Gas Dispositions by the Canada Oil and Gas Lands Administration (COGLA);
- Environmental assessment by the Federal Environmental Assessment Review Office (FEARO);
- Issuance of Certificates of Public Convenience and Necessity by the National Energy Board (NEB).

COMPONENTS OF THE NORTHERN ENVIRONMENT INFORMATION MANUAL

The Northern Environment Information Manual provides a single, concise source of information having two major components:

1) An "alert" system - comprising a series of regional-scale maps which identify the degree of concern for impact to the environment, thus focussing the attention of proponents and regulators on the potential "issues", or conflicts or constraints, if development is proposed;

2) A "gateway" system - comprising a fact sheet which details the nature of that concern and improves access to further information by listing relevant data bases, individuals or agencies to contact, and bibliographic references.

The alert maps include both a number of individual interpretations submitted by government resource agencies with a mandate or expertise in that aspect of the northern environment (e.g. terrain sensitivity or fish and wildlife habitat) as well as a composite map which integrates all of the interpretations (Figure 1). Inclusion of the theme maps or "overlays" permits the user of the Manual to refer to the original bases from which the composite was created.

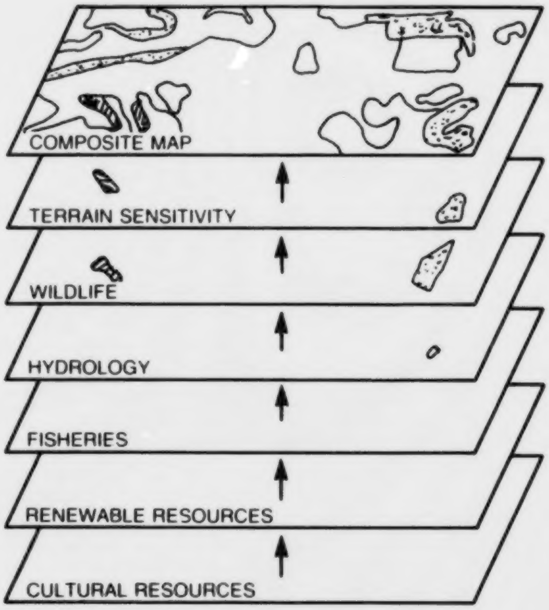

Figure 1. Composite map production process.

One standard "degree of concern" classification guides interpretation to produce the theme maps (Figure 2). The framework for this classification was established by the Edmonton Workshop, and is based primarily on that developed by Fisheries and Oceans Canada (DFO) to assist COGLA in the process of negotiation

Figure 2: Classification for the Northern Environment Information Manual based on the Degree of Concern for Potential Impacts and Example Criteria for Three Resource Interpretations

	Benchmark Conditions	Criteria for Resource Interpretations		
		Migratory Bird Habitat	Terrain Sensitivity	Water Resources
Red	. Area of exceptional value for conservation. . Environmentally unsuitable for exploration and/or development. . Commonly under legislative protection.			
Orange	. Area of exceptional value for conservation and/or area with severe environmental constraints to development. . May be environmentally suitable for exploration and/or development under strict operating controls. . Commonly recognized by conservation agencies or interest groups, but not always subject to specific or direct legislative protection.	Key habitat sites: sites which support at least 1% of a national population.	Tracked vehicles would be liable to churn the surface materials down to the frost table. Vegetation, which may be substantial, would be severely disturbed, including possible burial or shearing of upper plant from root systems. Extrusion of materials may occur to form a levee beside the twin channels created by the tracks. Gullying may occur following disturbance and thermokarst ponding may also develop. Changed drainage conditions may change the composition of the plant communities. Thaw-flow slides may be triggered either directly or following gullying or thermokarst development. Trenching may reveal considerable excess ice leading to major instability of trench walls and collapse due to thawing. Micromorphology would be destroyed.	Essential to maintain water quantity, quality and flow regimes for human uses and/or maintenance of critical wildlife and/or fish habitat.
Yellow	. Area of value for conservation and/or area with environmental constraints to development. . May be environmentally suitable for exploration and/or development under strict operating controls. . Commonly recognized by conservation agencies or interest groups, but not always subject to specific or direct legislative protection.	Other habitat sites which support a population representing less than 1% of a national population.	Tracked vehicles would be liable to furrow and locally churn the surface materials to the frost table. Vegetation which may have a high percent cover and be locally thick would be substantially disturbed, including possible local burying and severe stress on root systems. Plastic deformation of materials may occur locally and extrusion of levees beside the tracks may also occur. Gullying will develop in some materials following disturbance and thermokarst may develop. Local changes in drainage may cause changes in the composition of plant communities. Thaw-flow slides may sometimes be triggered. Trenching would reveal substantial segregated ground ice, locally in excess, which would lead to instability of the trench walls with potential collapse on thawing.	Important to maintain water quantity, quality and flow regimes for human use and maintenance of wildlife and/or fish habitat. Areas having terrain characteristics prone to erosion, increased siltation and drainage alteration.
Green	. Area of limited value for conservation and/or area of low environmental constraints to development. . Environmentally suitable for exploration and/or development under standard terms and conditions. . Areas not subject to specific or direct legislative protection.	Other areas.	Areas having no special susceptibility to degradation from tracked vehicle traffic or trenching.	Areas with no special water concerns.
White	. Area cannot be classified due to a lack of information.	Area cannot be classified due to a lack of information.	Area cannot be classified due to a lack of information.	Area cannot be classified due a lack of information.

of all hydrocarbon exploration and development agreements on Canada Lands (Wright in DPA, 1985). To produce their resource interpretations, participating agencies identify a "custom" set of criteria which allow them to apply the classification to their information. These criteria, along with the original benchmark conditions, will be explicitly detailed in the Manual. Examples of these criteria are presented in Figure 2.

A PROTOTYPE FOR THE VISCOUNT MELVILLE SOUND REGION

The initial test of the concepts inherent in a Northern Environment Information Manual focussed on the Viscount Melville Sound Region, Northwest Territories (Figure 3). Its scope was restricted to those themes within the mandate of the Environmental Conservation Service of Environment Canada. Therefore, the prototype illustrates the degree of concern held by the Lands Directorate, Inland Waters Directorate and the Canadian Wildlife Service, with respect to terrain sensitivity, water resources, and migratory bird habitat, respectively. Figure 2 presents the criteria used by each of the Directorates to classify the Sound Region. A reduced copy of the composite map which was compiled from the individual theme maps prepared by those Directorates, is displayed in Figure 4.

A number of significant points about the degree of concern classification, and this specific geographic area, become apparent from the composite map (the five categories of the degree of concern classification are referred to as colours in this commentary, even though the composite was reproduced in black and white for this paper):

- There are no areas which are unsuitable for exploration and/or development (identified as "red" category within classification). Due to the highly restrictive nature of this category, it should be reserved for lands of National Park or National Park Reserve status, none of which are located in the study region.
- Some areas on Melville, Bathurst, Prince of Wales, and Browne islands are of exceptional value for conservation and/or have severe environmental constraints to development (identified as "orange" category within classification). Special conditions prompt resource agencies to flag these prime areas as warranting particular attention if development is proposed in their proximity. Development is not necessarily prohibited, as long as mitigative techniques may be implemented to ensure that impacts are reduced to a level acceptable to the agencies responsible for those resources.

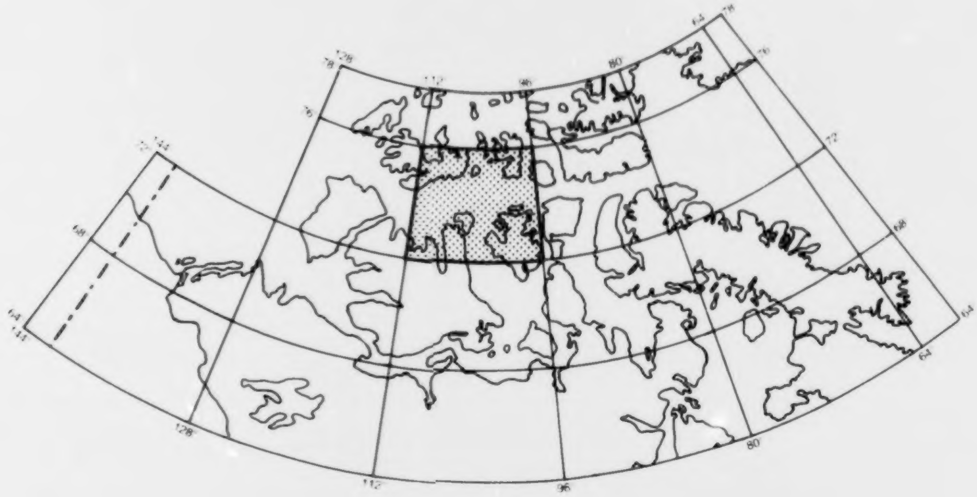

Figure 3. Location and Regional Setting of the Viscount Melville Region.

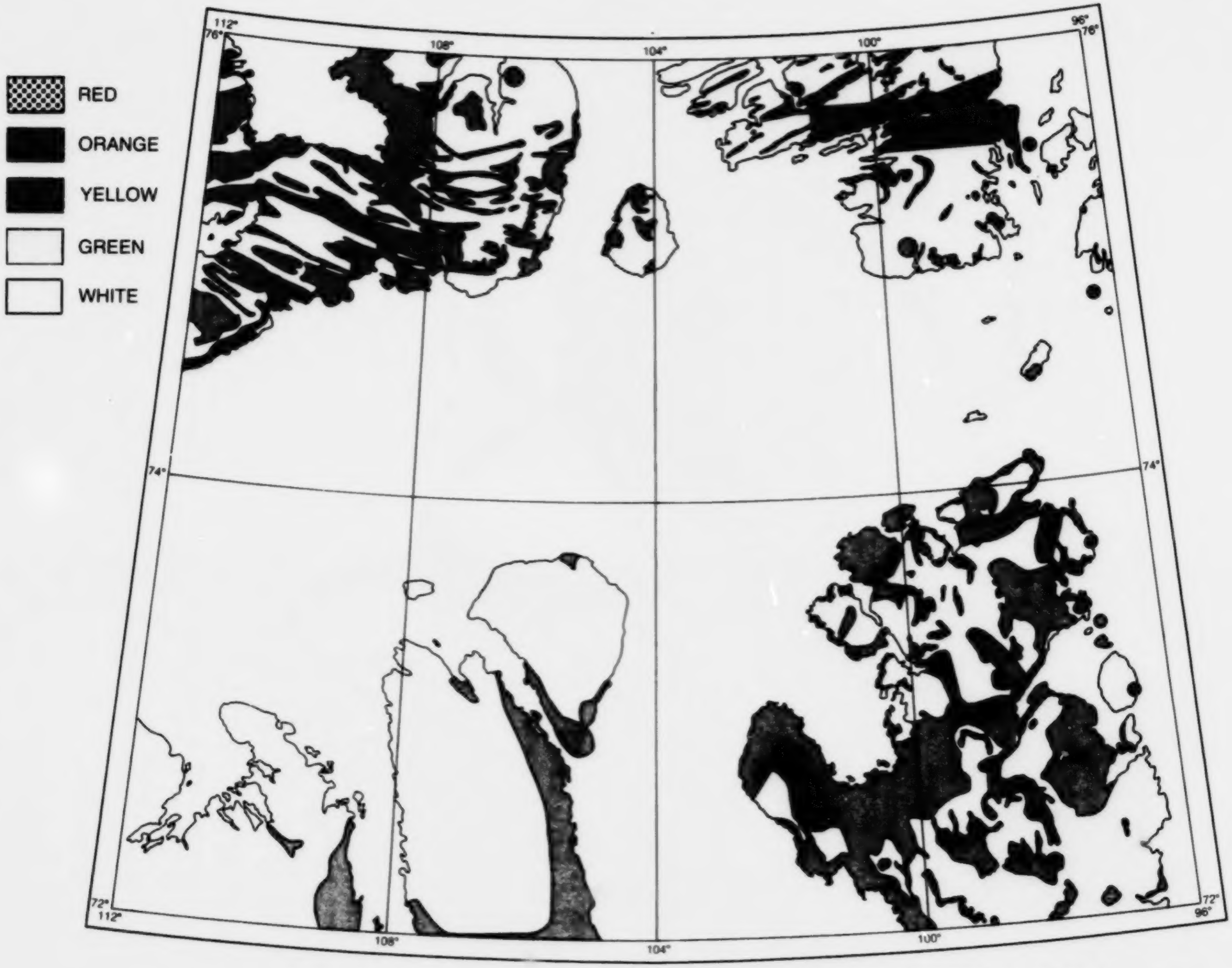
RED
ORANGE
YELLOW
GREEN
WHITE
112°
76°
108°
104°
100°
96°
76°
74°
74°
72°
112°
108°
104°
100°
72°
96°

Figure 4 "Alert" composite map for the Viscount Melville Sound Region (reduced from a scale of 1:1 000 000 for illustrative purposes).

"Exceptional" and "severe" are the important operatives in this class description.

- Polar Bear Pass is one such area of exceptional value for conservation and/or having severe environmental constraints to development. The nature of the concerns include its high value as wildlife habitat and presence of landforms and terrain conditions which are highly susceptible to degradation from exploration or development activities. Notwithstanding the high degree of concern indicated for the area, the source agencies indicate that the area may still be suitable for exploration and/or development under strict operating controls.
- The "yellow" category is also deemed "suitable for exploration and/or development under strict operating controls". The purpose of distinguishing these two categories was to allow agencies to differentiate their prime or priority areas requiring special attention. For example, it was important that the Canadian Wildlife Service distinguish its key sites for migratory bird habitat (with greater than 1% of the species population) and other habitat areas (hosting less than 1% of the species population), although both may require the imposition of operating conditions supplementary to those required in environments which do not support migratory bird populations. There appears to be a preponderance of areas in the Region of "value for conservation and/or having environmental constraints to development", including migratory bird habitat sites; sensitive terrain features such as those with high ground ice content and low bearing capacity; and sensitive hydrologic regimes. However, as noted in the fact sheets, the object of concern for many of these sites is seasonal in nature.
- Areas of "limited conservation value and/or of low environmental constraints to development" (identified as "green" category within the classification) occupy the largest proportion of the study area. The Environmental Conservation Service has not yet had reason to have any special concern for impact, beyond that accorded as a general principle to minimize environmental degradation.
- Portions of eastern Victoria and Stefansson Islands have not been classified according to degree of concern for impact due to a lack of information (identified as "white" category in the classification). Recognition of inadequate data for such purposes is valuable for both industrial proponents in siting a facility, or scientists in planning their research programs. For the majority of Northern Canada, however, there is much existing data to be organized.

CONCLUSIONS

Production of a Northern Environment Information Manual offers the following advantages to its users (i.e. petroleum industry development proponents and government agencies with advisory or regulatory authority in the areas of land use and environmental protection) and to the resource conservation agencies which contribute to it:

Users

- a clear and concise summary of environmental priorities and issues in the study region, providing a focus for preparation and review of development applications;
- guidance, in the form of the degree of concern classification, provided directly by the resource specialists with the best knowledge, understanding, and data to support these decisions;
- detailed references, data sources, and contacts for further information on resources of concern; and
- compatability and ease of integration with the DFO "Classification of Marine Habitat" project;

Contributors

- improved communication of their resource concerns and priorities to land use allocation decision-makers;
- a broad structure for organizing existing environmental data in a format useful to decisions at hand, and for organizing future data collection activities;
- a clear indication of topical and geographic areas where data and information are needed to ensure the best decisions;
- increased control over the interpretation of their baseline data in development planning and environmental impact assessment; and
- provision of an explicit stand on environ-

mental concerns to promote understanding of the issues, and cooperation among parties, in environmental problem-solving.

Further conclusions regarding the feasibility and effectiveness of the current Northern Environment Information Manual design will be drawn following an extensive review of the prototype by both potential users and contributors.

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STATUS OF UNITED STATES NATIONAL WILDLIFE AND FISH HABITAT INVENTORY AND EVALUATION ACTIVITIES

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INTRODUCTION

Wildlife and fish habitat inventories and analyses do not have a singular agency or coordinating committee focus in the United States. Responsibilities and activities are scattered across several federal and state agencies. As a result gaps and duplication of information exist for wildlife and fish resources. This administrative deficiency may be less significant than the lack of a consensus on the ecological basis for such inventories and analyses. There is the general perception that the more or less nationally and regionally consistent separate inventories for vegetation, water, soil, etc., can be meaningfully related to a definition of habitat for wild animals. Although consistency is valuable, sample design is critical for a meaningful interpretation. The lack of a theoretical basis for interpreting non wildlife and fish resource inventories leads to inadequate and inaccurate statements about wildlife and fish. The United States is not unique in respect to these problems. Without a national administrative and/or ecological framework for the design of wildlife and fish habitat inventory and analysis procedures, errors and difficulties will continue to occur in our interpretations.

The review of national habitat inventory and analysis activities in the United States that I provide here represent a select and partial set of the total effort that is carried out by federal, state, and private organizations. It represents the information I was able to acquire and will certainly contain gaps. The criterion I used to select inventory and analysis efforts for this report was that the effort had to be national in scope, it could vary by regions but I did not consider subregional (state or local) level efforts.

INVENTORY AND EVALUATION ACTIVITIES OF SELECTED U.S. FEDERAL AGENCIES

USDA Forest Service

The USDA Forest Service has two administrative branches which are responsible for nationwide multiple resource inventory and analysis on forest land. Both the research and national forest system branches administer and carry out these tasks on a regional basis.

The research branch has seven field inventory and analysis units that conduct the continuous multiple resource inventory on forestland. Coordination and standardization is covered in national and regional handbooks and manuals. The inventory is based on a point sample which varies in sample intensity depending on the vegetation and land base characteristics. Evaluation of the inventory produces information about the quantities of the land base in terms of land use, land cover, and trends in land use/land cover. Timber resources information is the principal interest in the inventory. Statistical summaries of information by forest type, ownership, site class, stand size, stand age, stand origin, etc., are commonly provided. Wildlife resource information describes habitat in terms of vegetation structure, composition, and density in the overstory, midstory, and understory. Presence of cavities, snags, holes, caves, dens, brush piles, hollow logs, and water are recorded at or around sample points. Evaluation of these inventory items can be made with habitat suitability index models for selected species. Range resources inventory measures the quantity, quality and distribution of vegetation suitable for livestock forage. Estimates of forage production are currently being added to the inventory of forestland. Recreation resource inventory items include evidence of uses such as hunting, fishing, and camping. Together with other information on presence of trails, water, slope, land use, vegetation, etc., estimates of recreation potential are provided. Water resources are inventories in terms of lake and stream categories and described by size or width, whether they are fresh or salt water, temporary or permanent, and the average depth of temporary water. Evaluation of the inventory for information about biomass, ecology, botany, and use interactions are also possible.

A series of references are appended to this discussion that can be consulted for a more detailed description of the inventory procedures and the typical types of evaluations that the forest inventory and analysis units perform. Persons who can be contacted in each inventory unit are also included in the appendix. An explanation will be given on how the Forest Service and Soil Conservation Service are using the information from the forest inventory together with information from other sources to support the National Assessment and Appraisal of Wildlife and Fish.

The National Forest System Branch has nine regions that provide guidance and control of the inventories carried out on each national forest. Coordination and standardization of the national forest inventory is covered in national and regional manuals and handbooks. Generally, the inventory provides much of the same basic information as just described for other ownerships of forestland. Somewhat less emphasis has been placed on a multiresource inventory in the past with separate inventories for each resource but this is changing. In respect to evaluation of wildlife and fish resources, the national forests have instituted the Wildlife and Fish Habitat Relationship Program (WFHR).

The WFHR Program is nationwide, but coordinated in each regional office. It was developed in response to the land management planning requirement on national forests. The method is based on labeling habitats according to dominant biological and/or physical attributes of sites and the specific environmental variables that are habitat resources for certain species. Some of the tools that are used in national forest assessments are:

1. Micro and minicomputer data bases that contain coefficients of the relative quality of each habitat class for each species.
2. Multi-stand habitat simulation models for cumulative benefits and effects analysis.
3. Habitat suitability index models to serve as the wildlife and fish production functions in multi-stand simulations.
4. Geographic information systems for species location data, habitat inventory, and spatial pattern analysis.

Tools such as these are used in integrated, multi-resource analysis procedures that convert initial habitat inventories to initial habitat capabilities and recreational use benefits for wildlife and fish management indicator species.

Three levels of detail for the biological and physical attributes of a site are evaluated in terms of diversity and selected species habitat capability for application in project and land use plans. Level 1 models develop habitat capability ratings for high, moderate, and low densities of species. Known population densities are required to calibrate the habitat capability ratings. Level 2 models are frequently those developed by others such as Habitat Evaluation Procedures and Pattern Recognition Models. These models are assumed to integrate habitat variables and rate these variables in terms of providing habitat requirements. Level 3 models serve the purpose of aggregating all habitats within one area such as a national forest. The approach developed by Jack Ward Thomas is one of several used for level 3 models. References to the WFHR work are provided in the appendix along with persons to contact in each of the regions for additional information.

USDA Soil Conservation Service

The USDA Soil Conservation Service has the responsibility for nationwide inventory of private lands. The inventory includes all land uses and vegetation cover types, however agriculture and range land have received greater emphasis than forestland. Coordination and standardization between the regional technical centers and states is covered in a national handbook. The inventory is based on a random sample of plots which vary in sample intensity and size in acres depending on the vegetation and land base characteristics. Evaluation of the inventory produces information about the quantities of the privately owned land base in the United States in terms of land use, land cover, and trends in land use/land cover. Agricultural cropland and range resources are the major focus of the inventory. Statistical summaries of information by crop and range type and productivity class are commonly provided. Wildlife resource information describes habitat in terms of vegetation structure, crop residues, and availability of water. Evaluation of these inventory items permits interpretations using habitat suitability index models for selected species. Range resources inventory measures the quantity, quality, and distribution of vegetation suitable for livestock forage. Estimates of forage production have recently been added to the inventory of rangeland.

References for documents which describe the inventory procedures and the typical types of evaluations that the USDA Soil Conservation Service National Resource Inventory provides are included in the appendix together with contact persons for additional information.

Earlier I mentioned that I would describe how the Forest Service and Soil Conservation Service are using the forest land inventory in the National Assessment and Appraisal of Wildlife and Fish. Since wildlife and fish habitat incorporates the land use and land cover from the total land base, the Forest Service and Soil Conservation Service did two things. First, the Forest Service and Soil Conservation Service agreed to work jointly on a National Assessment and Appraisal of Wildlife and Fish Resources. This secondarily facilitated the development of joint analysis procedures which utilize the combined land and resources inventories both agencies carry out nationally.

The land classification needed to combine the inventories of the USDA Forest Service and Soil Conservation Service being used in the Assessment and Appraisal were described by Chalk et al. (1984). At the most generalized level, the land base is described by a matrix with land use on one axis and land cover on the second axis. The land cover axis is further defined for forest and cropland by forest type and type of crop present and structural vegetation descriptors such as age, volume, height, etc., for woody vegetation and height for crop vegetation. The analysis procedures which are used to interpret the inventory are principally multivariate statistical techniques which relate current wildlife occurrence and abundance to the current land base inventory at a regional scale.

USDI Fish and Wildlife Service

The USDI Fish and Wildlife Service has principle responsibility for non-resident wildlife and fish resources in the United States. States have the responsibility for resident wildlife and fish resources. Laws, treaties, and memoranda of understanding define these responsibilities specifically but the focus tends to be more on the animal itself than is the case with other federal agencies which have tended to emphasized habitat. The USDI Fish and Wildlife Service carries out or participates in several national and international inventories or censuses of wildlife and fish populations. The National Wetland Inventory is the major ongoing habitat inventory. The USDI Fish and Wildlife Service has also been actively involved in the research and development of evaluation and analysis methods such as the Habitat Evaluation Procedures (HEP), Instream Flow Incremental Methodology (IFIM) and Physical Habitat Simulation Modeling (PHABSIM).

The National Wetland Inventory objective is to quantify the status and trends of wetlands in the United States The inventory organizes information according to the classification of Cowardin et al. (1979). To date approximately 40 percent of the lower 48 states and 10 percent of Alaska are completed. Several special studies are also underway including: A pilot study on the status of wetlands in Alaska; intensification of the inventory for the five state area around Chesapeake Bay; the prairie pothole region; and documentation of wetland values studies throughout the United States. The emphasis of the Wetland Inventory is on the coastal zone, flood plains of major rivers, and USDI Fish and Wildlife Service priority areas based on various planning efforts. Reference documents and contact persons are listed in the appendix.

The USDI Fish and Wildlife Service developed Habitat Evaluation Procedures for use in evaluation of project impacts. The method is based on a species-habitat relationship that assumes optimal habitat for a species can be defined and that comparisons can be made between actual on-site conditions and the optimum. The Habitat Evaluations Procedures establish a habitat suitability index value for a give species and combines the index value with an area measurement to given a habitat suitability per unit of area index as a final output. The method assumes that this unit value is directly related to carrying capacity. The species habitat relationship used in the Habitat Evaluation Procedures are location specific.

Reference documents which describe the analysis procedures and some examples of the models that have been published based on the procedures along with contact persons are included.

USDOD Army Corps of Engineers

The U.S. Army Corps of Engineers developed an evaluation procedure called Habitat Evaluation System for planning purposes. The Habitat Evaluation System is based on a series of graphical relationships between key variables such as percent overstory, number of snags, percent understory for major habitat types, and suitability indices for those key variables representing their suitability for wildlife. The relationships are determined from literature sources and expert opinion. The Habitat Evaluation System describes habitat quality for a broad range of species rather than for individuals or groups of species. The output is a composite habitat suitability index ranging from 0 to 1 for each major habitat type. The relationships used in the Habitat Evaluation System are based on conditions in the lower Mississippi River Valley where the system was developed. Consequently, applications to other areas require modifications.

Reference documents which describe the analysis procedures in detail and contact persons are included in the appendix.

USDI Bureau of Reclamation

The Bureau of Reclamation has initiated a research project to develop a Habitat Management Evaluation Model. The objective is to provide habitat management guidance to a land manager in answering the following type of questions: Given some habitat management objective to be achieved, what is the most cost-effective means of achieving that objective?

The Habitat Management Evaluation Model is comprised of three major components.

1. Habitat Suitability Index Models
2. Habitat Management Models
3. Economic data for specific habitat management actions.

The Habitat Suitability Models are those developed by the USDI Fish and Wildlife Service which describe mathematical relationships between habitat variables and overall habitat value.

Habitat management models are similar to HSI models except that they describe functional relationships between a specific habitat management action and one or more habitat variables contained in the HSI model.

The third major component of Habitat Management Evaluation System provides managers with information regarding unit casts of selected management actions.

The Habitat Management Evaluation Model System is designed to serve as a gaming tool for habitat managers. The system allows managers to perform sensitivity analyses on individual habitat management actions. Outputs give managers insights into how habitat value would change for each additional increment of management action applied, assuming current habitat conditions to begin.

As I said at the outset, I have reviewed a selected group of agencies and the methods they use. Other agencies are also involved in developing inventories of renewable resources and evaluation procedures. This includes agencies such as the USDI Bureau of Land Management, Tennessee Valley Authority, US Geological Survey and the US Environmental Protection Agency.

SELECTED REFERENCES FOR INVENTORY AND ANALYSIS PROCEDURES IN THE UNITED STATES

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USDI Fish and Wildlife Service

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USDI Bureau of Reclamation

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APPLICATION OF THE HEP HABITAT LAYERS MODEL TO GIS TECHNOLOGY

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ABSTRACT

This study (in progress) investigates the integration of wildlife habitat layer components into ecological land classification for planning purposes. The purpose of the study is to use existing information and to generate habitat layer index (HLI) data necessary to evaluate the application of the HLI model in classification of wildlife habitat over large areas, using remote sensing and GIS computer techniques. Methods include use of the HEP habitat layers model in interpretation and classification of medium-scale (1:80 000) color-infrared photos, large-scale (1:12 000) color photos, and (1:5 000) black-and-white orthophotos for application to ESRI's ARC/INFO (version 3.1). Habitat in the 1378-ha (3 441 ac) Clay Brook watershed in the upper Mad River Valley in central Vermont was classified according to the HLI model as modified for aerial photointerpretation and according to a modified U.S. Geological Survey (USGS) land use/cover classification done by the Vermont GIS Program at the School of Natural Resources of the University of Vermont. A vegetative cover data layer created for the Mad River Valley research area in a demonstration project by the Vermont GIS Program was used as well. Preliminary data analysis indicates that the HLI model is particularly applicable to the early stages of development planning. The level of habitat diversity desired will depend on planning and/or management needs. Low HLI values, such as that for the Clay Brook watershed as a whole (0.28), may indicate that present habitat conditions are favorable to wildlife dependent on large, relatively undisturbed areas. Possible wildlife planning needs resulting from development in the Clay Brook watershed will be modelled and mapped with ARC/INFO.

SCOPE OF PROJECT

The project is an expansion of ongoing studies in the application of ecological principles to large-scale comprehensive forest land planning. The umbrella research program at the University of Vermont (Hendrix, 1984) accommodates three hierarchical levels of research: (1) ecological land classification; (2) transactions between the components of the ecological land classification system; and (3) the movement of energy and materials into and out of a geographically defined ecosystem. This study addresses the first level of research in terms of wildlife planning with an applied, nontheoretical multiresource orientation.

The existing data base for the ongoing research in the Clay Brook watershed in the Mad River Valley (Fig. 1) include land use, slope, stream order and class, highways and roads and their

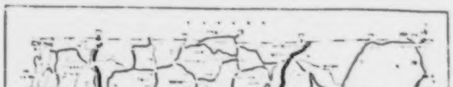

Figure 1. Location of Clay Brook watershed.

order and class, highways and roads and their surface types, well locations, elevations, and soils. No data yet have been acquired to include faunal characteristics in the classification models being developed in the first level of research. The 1974 Forest and Rangeland Renewable Resources Planning Act of the U.S. Congress mandates management for biological diversity of wildlife as one of the multiple resources of federal forest lands. Large-scale land use planning is in progress for the U.S. Forest Service land under the National Forest Management Act of 1976 (Hendrix, 1984). Wildlife resource data are an important aspect of multiple resource planning.

This study uses a habitat evaluation model in creating a data layer of classified wildlife habitat. This will facilitate the inclusion of wildlife resources in ecologically based planning and impact assessment in an area currently under intense development pressure. Future research will be left to address problems of guild development for species selection (Block et al., 1984; Mannan et al. 1984; Roberts and O'Neil 1985; and DeGraaf and Chadwick 1984) in modelling and prediction of project impacts (Hawkes et al. 1983) on wildlife habitat and populations. This study is restricted to application of the U.S. Fish and Wildlife Service Habitat Evaluation Procedures habitat layers model to GIS technology.

THE HEP SYSTEM

The HEP "accounting procedure" (Schamberger and Krohn 1982) is based on habitat quantity measures combined with a habitat suitability index (HSI) to determine habitat values for species or guilds in question: habitat area x HSI = habitat units (HUs). HSIs can be determined by several documented methods that include models of quantified evaluation criteria. HSI is a value between 0.0 and 1.0. Assuming HSI is positively correlated to habitat carrying capacity, 1.0 is the maximum habitat quality in a given area. In an evaluation, HU data are generated for each species, life requisite, life stage or guild in question (Schamberger and Krohn 1982). Study objectives and evaluation species must be very carefully chosen. HEP "accounting" is computerized to aid in calculating HUs and to perform other data manipulations for baseline and impact studies.

For purposes of this study (creation of a data base for multiresource planning), ecological community-based HSI models are most appropriate. Single-species models require interspecific extrapolation of data if the management goal is species diversity, or if management indicator species are used. HEP evaluation species can be selected for sociopolitical, ecological, or economic reasons. Roberts and O'Neil (1985) note that HEP is species-based but that it can focus on either wildlife or vegetation. This is desirable, but "many biologists feel that because HEP is a 'wildlife' habitat evaluation method, the emphasis should be on the animal community with the plant community given only secondary consideration" (Roberts and O'Neil 1985:5). This would be true of single-resource planning such as for a wildlife refuge, but would be unnecessarily restrictive for multiresource planning. These difficulties and difficulty with guild development prompted the choice of the habitat layers model (Short and Williamson 1984) for this study over the Arizona guild HSI model (Short 1984), the two community-based HSI models currently available. "The comprehensive study requiring broad ecological perspective has been particularly troublesome for many HEP planners" (Roberts and O'Neil 1985:17). This study may be no exception, but it will provide feedback on the application of the habitat layers model to planning integrated with ecological land use classification and GIS technology.

GIS TECHNOLOGY

Gates and Heil (1980:105) point out that "GIS technology does not represent a single technological approach nor is it a homogenous technological arena." GIS technology uses spatial data which is useful in creating, designing, and evaluating land use plans, impact analyses, capability/suitability analyses, etc. Spatial data combines both a measurement of an attribute and the geographic location of that attribute and is usually organized in a map framework (Gates and Heil 1980). Basically a GIS data base must be able to produce derived data and information including mapped displays of geographic data different from the basic data. Recent advances in the merging of computer graphics and data base management have made GIS technology practical and more cost-effective in application (Erdle and Jordan 1984). However "the true test of any GIS is the extent to which it gets used to deal with problems based on spatial data" (Gates and Heil 1980:115).

Erdle and Jordan (1984) describe building a GIS data base for inventory-related data, as applied in the New Brunswick forest protection program. Geographic location data are collected in digital form by identifying lines on a map (arcs), which are defined by coordinates of starting and ending points (nodes) and changes in direction (vertices). Measurement of data is done through digitizing, which may be manual or automated scanning, in which coordinate number pairs of locational information are stored in a computer. Once all arcs have been digitized they are edited electronically to remove errors, and are stored unassociated and unstructured. They are then assembled electronically in polygons, lines, or points to represent spatial relationships. Attribute data, acquired by photointerpretation and/or ground sampling, are then coded and entered via keyboard into the computer. The identification code of the attribute data is the link between geographic location and descriptive attribute data.

Data base use involves amalgamation, modelling, and aggregations or map merging, reclassification, overlay, data search, and updating (Erdle and Jordan 1984). Some part of the basic data base is reformatted to create new information. Maps may be combined or windowed (focused on a subset of a geographic area). Data can then be reclassified to infer new characteristics about a given feature, such as susceptibility to spruce budworm. Data can be aggregated in an overlay procedure that creates new variables. The data base can also be searched for a particular geographic location with given attributes and updated, replacing old data without aggregating. Tabular summaries from a GIS provide quantitative data whereas computerized maps show the spatial data distribution. The real power of GIS technology is the opportunity to analyze information inherent in map structure, not necessarily displayed on the map (Erdle and Jordan 1984).

The Vermont GIS

In 1979 the University of Vermont began to consider the acquisition of a GIS for use in natural resource planning with emphasis on problems of developing rural areas. In 1980 the University of Vermont bought GIS software and hardware. Software includes both grid and polygon-based systems (Hendrix and Newton 1984). "Data entry methods include manual digitizing, raster scanning followed by vector conversion, incorporation of existing computer formatted information and digital... satellite imagery" (Smith and Hendrix 1985:1). Hardware includes a VAX 11/750 minicomputer, a Talos digitizing tablet, a 4-pen COMPLOT drum plotter, and a Tektronix 4112A graphics terminal.

In 1981 a project was begun to demonstrate the use of GIS technology in rural natural resource planning in Vermont (Hendrix and Newton 1984). Initial data layers formed the basis for derivation of others. Ultimately the original data layers and those derived formed a data base of 12 layers available for analysis (Fig. 2). Aspect, elevation, and slope were derived from topography; stream order and water quality and road type and surface information are available as well (Hendrix and Newton 1984). The sources of the data layers are shown in Table 1. Applications of the GIS have since been made in timber management, highway corridor alignment, agricultural land assessment, zoning changes, and visual resource management (Hendrix and Newton 1984). In 1983 the University and the U.S. Soil Conservation Service entered into a cooperative agreement for data entry into a statewide GIS data base (Smith and Hendrix 1985). Other applications recently made include "watershed management, groundwater modelling, evaluation of resource sampling and measurement procedures, and development of ecologically based forest land planning models" (Hendrix and Newton 1984:6). The GIS is viewed as an important part of natural resources management in a rural state in which the natural resource base is extremely economically important (Hendrix and Newton 1984).

GIS and Habitat Inventory

Mayer (1984) states that a GIS system used for wildlife habitat inventories should be able to handle vector data (line segments created from polygon data), raster data (in cellular or point format), tabular/textual data, and digitized wildlife species occurrence data (vector data) being processed to produce qualitative and quantitative assessments. This is the type of approach taken in some of the

Table 1. Data Layers and Sources

Data Layer	Source
Geology	Mad River Valley Growth Study Plan, Central Vermont Regional Planning
Highways and Roads	Vermont Department of Transportation
Land Use	University of Vermont School of Natural Resources, Remote Sensing Applications Program
Streams and Rivers	USGS
Soils	SCS
Topography	USGS
Well Locations	Vermont Water Resources
Wetlands	National Wetland Inventory
Zoning	Mad River Valley Growth Study Plan

From Hendrix and Newton (1984)

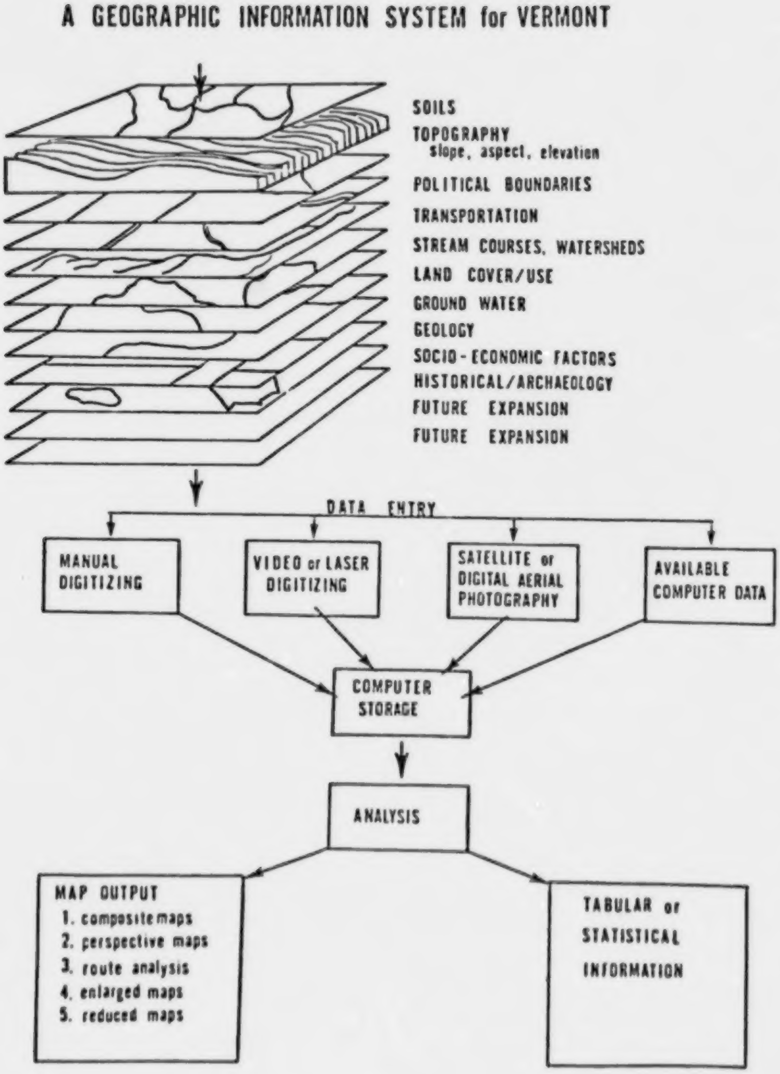
A GEOGRAPHIC INFORMATION SYSTEM for VERMONT
SOILS
TOPOGRAPHY
slope, aspect, elevation
POLITICAL BOUNDARIES
TRANSPORTATION
STREAM COURSES, WATERSHEDS
LAND COVER/USE
GROUND WATER
GEOLOGY
SOCIO-ECONOMIC FACTORS
HISTORICAL/ARCHAEOLOGY
FUTURE EXPANSION
FUTURE EXPANSION
DATA ENTRY
MANUAL DIGITIZING
VIDEO or LASER DIGITIZING
SATELLITE or DIGITAL AERIAL PHOTOGRAPHY
AVAILABLE COMPUTER DATA
COMPUTER STORAGE
ANALYSIS
MAP OUTPUT
1. composite maps
2. perspective maps
3. route analysis
4. enlarged maps
5. reduced maps
TABULAR or STATISTICAL INFORMATION

Figure 2. Conceptual Configuration of the Data System (Vermont GIS Program, University of Vermont).

existing applications of GIS technology to wildlife inventories for planning and impact assessment, and species/habitat relationships. One example of a state-wide application is the Colorado Division of Wildlife's Wildlife Resource Information System, which includes an inventory data base and a GIS to enter, store, retrieve, and analyze population/distribution information (Shrupp 1982). Two habitat identification approaches are used. In one, data are structured to display field-observed seasonal, functional, and distributional variations in species use of habitats, with mapped areas grouped categorically (Shrupp 1982:168). The other approach models separate habitat components such as food, water, and cover, to predict species distribution. This is made possible by GIS capability to iteratively display and analyze interrelationships of multiple habitat factors. Future use will probably include a hybrid of the two approaches (Shrupp 1982). Thus GIS technology can help to expand the "snapshot-in-time" offered by both qualitative and multivariate statistical approaches to habitat evaluation (such as HEP) to model resources management alternatives to gauge impacts on wildlife habitat and populations (Patch 1984).

PROCEDURES

Description of Study Area

Hendrix and Newton (1984) have described the Mad River Valley research area. The upper valley is of particular interest, an area of 21,016 ha (51,930 ac) in the towns of Fayston, Waitsfield, and Warren. The Clay Brook watershed in the town of Warren (Fig. 1) is the study area of interest here, an area of about 1378 ha (3441 ac). The land cover/use is a mixture of forested, agricultural, and developed areas, in a mixture of private, local, state, and federal ownership. The topography includes flat floodplain areas in the river valley to very steep slopes rising to the crest of the Green Mountains. The area's population is less than 3000, with an economy based on agriculture, forestry, light manufacturing and winter sports. The area is experiencing increased development pressure because of expansion of the major winter sports facility. Jobs and second homes are expected to increase, along with pressures to supply additional municipal services. Impacts on the natural resource base will also occur, with far-reaching implications for the future of the valley.

Preliminary Data Collection

The data were collected in four major steps: (1) delineation of the existing classified and mapped polygons of the Clay Brook watershed on USGS 1:24,000 topographic base maps via 1:80,000 color-infrared photos; (2) preparation of a more detailed base map from 1:5,000 black-and-white orthophotos for digitization into GIS program ARC; (3) gathering of habitat data via interpretation of 1:12,000 color photos for attribute tables to be entered into GIS program INFO as Level IV HLI classification data; and (4) output of ARC/INFO maps showing integration of wildlife habitat data with ecological land use/cover classification.

The study used existing information and generated new data when necessary. The study area was classified with the Michigan system (based on USGS) to Level III for forest land and some residential areas, and to Level IV for other residential and all urban areas. New data were needed for areas lacking Level IV classification and for all areas without Level IV habitat data.

HLI Data Collection

The data collected were determined by the inputs to the HEP habitat layers model (Short 1984). The model is based on the assumption that nonfish vertebrate wildlife species use habitat resources along a vertical dimension that can be represented as habitat layers. In this model cover types are considered to be combinations of these habitat layers, or volumes of space at different levels above or below air-land or air-water surface interfaces. A layer of habitat is considered to be present if it occurs in a polygon above a given threshold. This concept of cover types is different from the traditional concept of horizontal vegetative cover. Cover type is here defined as any combination of somewhat arbitrarily defined vertical volumes of space. These volumes are then mapped as areas enclosed by polygons and provide data to classify the polygons.

The criteria for defining each habitat layer in this study were derived from several sources (Table 2). The habitat layer criteria used by Short (1984) were assumed and not tested, but were modified for use with photointerpretation (except the stream buffer zone) since time and funding constraints prevented detailed ground measurements. The basic habitat layer index equation (Short 1984) is as follows.

HLI = (number of layers actually present) x (area of each actual layer) : (number of layers potentially present) x (area of each potential layer)

Thus the numerator is the product of the number

Table 2. Modification of the HEP habitat layers model for use with photointerpretation.

Layer	Variable measured	Criteria	Criterion source
Overstory	Crown closure Crown diameter Tree height	More than 5% cover 1.5 m (5 ft) classes More than 7.6 m (25 ft)	Short, 1984 Avery, 1978 Short, 1984
Shrub layer	Crown closure Crown diameter Tree height	More than 5% cover 1.5 m (5 ft) classes More than 7.6 m (25 ft)	Short, 1985 Avery, 1978 Short, 1984
Herbaceous layer	Crown closure	More than 5% treed	Short, 1984
Standing water	Area	No outlet	USGS topo map
Running water	Area	Outlet(s) Buffer zone	USGS topo map Field measurement of stream width
Terrestrial surface	Area	Watershed boundary	USGS topo map

of layers and each layer's area actually present and the denominator is the product of the same in terms of potential occurrence in the most structurally complex cover type that could theoretically occur in the study area. The equation has been modified for use in this study by changing the coefficients of the denominator from the example used by Short (1984), which was drawn from the western U.S. An HLI value was calculated for the entire watershed and for each polygon. The HLI values and individual cover type data for each polygon will be input into hierarchical attribute tables for INFO and entered via keyboard into the computer.

The data and collection methods for HLI photointerpretation are shown in Table 3. These methods were based on modification of the HLI discussed above and standard methods found in Avery (1978). Tree height in this study was considered to be total height and not merchantable height because the former was used to distinguish between overstory and shrub layers for HLI calculation. Areas of USGS-classified polygons and an arbitrarily defined stream buffer zone were also required to calculate HLIs. Streams as defined by mapping rules discussed below would appear only as lines in ARC/INFO maps otherwise.

Table 3. Data and collection methods for photointerpretation of Clay Brook watershed.

Habitat layer	Attribute variable	Method of measurement
Overstory	Crown closure Crown diameter Tree height	Density scale Crown wedge or dot scale Parallax wedge
Shrub story	Crown closure Crown diameter Tree height	Density scale Crown wedge Parallax wedge
Herbaceous story	Crown closure	Density scale
Standing water	Area of water body	Dot grid (16 dots/in^2)
Running water	Area of buffer zone	Dot grid
Terrestrial surface	Area of USGS-classified polygon	Dot grid

Classification and Mapping Rules

Consistency in classification and mapping is ensured by abiding by explicit rules developed from the data and materials used, i.e., study needs and mapping conventions. The prior-classified polygons were classified according to a common method known as dominant land use (DLU). Here an area's dominant feature is assigned as the classification category based on area measurements (Table 4). The rules used in this study were taken from those used for the University of Vermont demonstration project in the Mad River Valley. They were used to classify polygons according to Level IV HLI data and then to map the polygons at 1:5,000 for a detailed base map. All forest and agricultural areas greater than 0.4 ha (1 ac) were mapped. This was done so that areas straddling the border of the watershed would be mapped and no "holes" would be created for later ARC digitization. All urban, residential, and recreational areas were mapped as found on the 1:24,000 mylar overlay map of the town of Warren made for the demonstration project. Linear features such as streams and roads were mapped as shown on the USGS topographic maps. Ski trails that were at least 15.2 m (50 ft) wide were mapped as shown on the orthophotos. This criterion was chosen for ease of digitization, i.e., having fewer small polygons due to narrow ski trails.

HLI Sampling by Photointerpretation

For Level IV HLI data, a stratified random, preliminary sample will be done to determine variability in the parameters measured and the six land use/cover classes: forest, agricultural, urban, residential, recreational, and winter sports areas. These classes were chosen because of the planning orientation of this study, thus ensuring that human use areas were not lost in sampling because of their relatively small areas as compared to forest land. Stratification also reduces sampling error if strata are defined so they contain relatively uniform sampling units and each unit is sampled individually (Myers and Shelton 1980).

Stratified random sampling was then set up via random numbers on a 16-dot/in.^{2} grid for point sampling within all prior-classified polygons after a sample size for each stratum was determined (Table 5). Sample size can be determined for the accuracy level desired (Myers and Shelton 1980), usually 90-95% levels. Point sampling allowed complete coverage of each polygon for classification accuracy and ARC/INFO modelling. Point samples are often used to represent areal data (Myers and Shelton 1980). Randomization reduced problems of systematic bias due to existing topography (Myers and Shelton 1980) with the north-south trending mountains and generally eastward stream flow found in the study area.

Interpretation techniques can affect land use mapping accuracy. Best results with the USGS system and a grid cell matrix are not always obtained with the smallest cell size and techniques less complex than stratified systematic unaligned sampling can produce more accurate data (Henderson 1980). Two habitat evaluation studies including classification accuracy testing report using confidence

Table 4. Example of classification rules for prior-classified polygons.

Level I	Level II	Level III	Criterion
4 Forest	41 Broadleaved forest	411 Upland hardwoods	More than 70% area covered
	42 Coniferous forest	421 Upland conifers	More than 70% area covered
	43 Mixed forest	431 Hardwoods predominate	Neither of above and more than 50% area covered by hardwoods
		434 Softwoods predominate	Neither of above and more than 50% area covered by softwoods

Table 5. Stratification of prior-classifed polygons by land use/cover type with approximate areas and sample size determination for Clay Brook watershed.

Stratum	Classification	Area		Sample Size Determination
		Ha	Ac	
Forest	411 Upland hardwoods	507.7	1269.3	Accuracy level formula[1]
	421 Upland conifers	45.9	114.8	
	431 Mixed woods, mostly hardwoods	185.7	464.3	
	434 Mixed woods, mostly softwoods	387.5	968.7	
Agricultural	2129 Other pasture	7.6	19	As mapped at 1:5,000
Urban	1167 Motel	14.4	36	Accuracy level formula
	1241 Central business district	1.1	2.75	
	127 Indoor recreation (public)	1.5	3.75	
	1425 Mass transport	3.8	9.5	
	1448 Public parking	3.9	9.75	
	1466 Water treatment	4.0	10	
Residential	112 Multifamily	10.1	25.3	Accuracy level formula
	1121 High-density apartments	14.3	35.8	
	113 Single family	47.7	119.3	
Recreational	1931 Landscaped/aesthetic	1.7	4.3	Accuracy level formula
	1933 Ski trails	92.4	231	
	1933 Golf course	46.1	115.3	
Water	52 Buffer zone	39.2	98	As mapped at 1:5,000
	52 Lake/pond	0.4	1	

[1] Myers and Shelton (1980).

intervals of 95% (Fine et al. 1978) and 90% (Todd et al. 1980). Similar levels of accuracy testing were attempted in this study. The DLU method of classification used in this study is an areal sample and was previously used in the Vermont demonstration project to generate prior-classified polygons. It was used again to generate Level IV HLI data since point sampling was used to represent areal data at Level IV. Random placement of grid cells over the study area photos will be attempted here. However, Henderson (1980) found that placement is a nonrandom decision in some cases and the optimum interpretation technique varied inconsistently among site and category tested.

DATA ANALYSIS

Examples of ARC/INFO modelling and mapping with the HLI data will be developed showing integration of wildlife habitat data with ecological land use classification. Possible wildlife planning needs due to development in the Clay Brook watershed will be identified by consulting with the Central Vermont Regional Planning Commission, the Green Mountain National Forest, and the Town of Warren. Detailed conclusions about application of the habitat layers model in integration of wildlife habitat into ecological land use/cover classification via GIS technology will then be drawn. The habitat layers model emphasizes the vertical structural diversity of a habitat and provides a measure of such diversity (Short 1984). The level of diversity desired will depend on planning and/or management goals determined by habitat area mitigation and compensation for development-related changes. Low HSI values such as that found for the Clay Brook watershed as a whole (0.28) may indicate that present habitat conditions are favorable to wildlife dependent on relatively large undisturbed areas. Preliminary analysis indicates that the habitat layers model is particularly applicable to the early stages of development planning (Short 1984). However, the model should be modified when ground sampling is impractical. This is useful for low-resolution planning with "site-species methodology" (Coulombe 1978) or "moderate" to "large" project areas (405-405,000 ha; 1012.5-1,012,500 ac; Mayer 1984).

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RÉSUMÉ

Cette étude (actuellement en cours) porte sur l'intégration de la stratification de l'habitat faunique à la classification écologique du territoire, à des fins de planification. Son objet est d'utiliser les données existantes et d'obtenir les données nécessaires sur l'indice de stratification de l'habitat (Habitat Layer Index -- HLI) pour évaluer l'application du modèle HLI à la classification de l'habitat faunique sur de vastes régions, au moyen de la télédétection et des techniques informatiques du programme SIG (Système d'information géographique). Les méthodes comprennent l'utilisation d'un modèle de stratification de l'habitat (établi au moyen de méthodes d'évaluation de l'habitat) (Habitat Evaluation Procedures -- HEP) pour interpréter et classer des photographies infrarouge couleur à moyenne échelle (1:80 000), des photographies couleur à grande échelle (1:12 000) et des photographies noir et blanc (1:5 000), destinées à l'ARC/INFO du Earth Science Resource Institute (version 3.1). L'habitat dans le bassin versant du ruisseau Clay (1 378 ha, soit 3 441 acres) dans la vallée du cours supérieur de la rivière Mad, située dans la partie centrale du Vermont, a été classé selon le modèle HLI modifié en fonction de l'interprétation des photos aériennes et selon une classification modifiée de l'utilisation des terres/couvert végétal du U.S. Geological Survey (USGS), réalisée à la School of Natural Resources de l'Université du Vermont dans le cadre du programme SIG. On a également utilisé une stratification des données relatives au couvert végétal créée pour la zone de recherche de la vallée de la rivière Mad, au cours d'un projet de démonstration réalisé dans le cadre du programme SIG du Vermont. D'après l'analyse préliminaire des données, le modèle HLI peut s'appliquer tout particulièrement aux premières étapes de la planification. La diversité de l'habitat sera plus ou moins importante selon les besoins de planification et/ou de gestion. Un HLI peu élevé, comme dans le cas de l'ensemble du bassin versant du ruisseau Clay (0,28), pourrait indiquer que les conditions actuelles de l'habitat sont propices aux animaux qui ont besoin d'une grande région relativement peu perturbée. Les besoins éventuels en matière de planification de la faune, résultant de la mise en valeur du bassin versant du ruisseau Clay, seront modélisés et cartographiés avec l'ARC/INFO.

AN APPROACH TO LAND/WILDLIFE INTEGRATION IN THE NATIONAL PARKS OF ARGENTINA[1]

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ABSTRACT

This work is a preliminary attempt to fill a gap in land/wildlife integration in Argentina. Some authors have attempted to organize and evaluate the wildlife by focussing on the life history of the species, but most work has concentrated on taxonomy. The present ad hoc methodology is based on local and foreign literature, personal field observations, and experiences of colleagues. When the literature was from other areas, extrapolations were made very cautiously. Once the methodology becomes well established, it will be extended to all the national parks in Argentina.

The example provided is for Rio Pilcomayo National Park. It considers only birds and large or medium-sized mammals. Results are expressed as food-locomotion matrices and other types of matrices. A matrix for reproduction and refuge is currently being developed. Through the analysis of each matrix, it is possible to obtain data about guild diversity, dominant means of locomotion, and species diversity. It is also possible to identify species with conservation problems due to high ecosystem pressure, such as cattle ranching, which is very common in some protected areas.

RÉSUMÉ

Ces travaux constituent une tentative préliminaire pour combler les lacunes qui existent dans l'intégration terre-faune en Argentine. Certains auteurs ont essayé d'organiser et d'évaluer la faune en étudiant principalement l'histoire naturelle de l'espèce, mais la plupart des recherches ont été axées sur la taxonomie. Les méthodes appropriées actuelles sont basées sur la documentation locale et étrangère, sur des observations personnelles sur le terrain et sur l'expérience de collègues. Lorsque la documentation provenait d'autres régions, on effectuait alors des extrapolations très prudentes. Une fois bien établies, les méthodes sont appliquées à tous les parcs nationaux d'Argentine.

L'exemple présenté ici est celui du parc national Rio Pilcomayo. Il ne tient compte que des oiseaux et des mammifères de moyenne à grande taille. Les résultats sont exprimés sous forme de matrice alimentation-locomotion et d'autres types de matrices. On élabore actuellement une matrice protection sanctuaire. L'analyse de chaque matrice permettra d'obtenir des données sur la diversité des regroupements, les principaux moyens de locomotion et la diversité des espèces. Il est également possible d'identifier des espèces dont la conservation est menacée en raison de fortes contraintes qui s'exercent sur leur écosystème, comme l'élevage du bétail qui est très répandu dans certaines régions protégées.

BACKGROUND

The first integrated ecological studies (Australian Land System) conceived of integration without including wildlife. There were, and in fact still are, many reasons for this, such as lack of precise data on wildlife, the need for long periods of field study to deal with it, lack of specialists, etc. However, in the last few years in Australia, the United States, Canada, and other countries, many approaches to filling this void have been developed.

In Argentina, although previous integrated ecological studies exist, they seldom considered wildlife, and where they did, the

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[1] Original text submitted in Spanish; translated to English by Barbara Duffus, Translation Bureau, Alberta Federal and Intergovernmental Affairs, Edmonton.

accuracy of the data was poor. This is because knowledge of the relationships of animal species with their environments is superficial, and therefore long and costly field research is needed. Nevertheless, in the last few years, such data have been increasing, and publications, although scarce, do exist. It is not always easy to gain access to such publications and they generally do not meet all our needs. Likewise, data of an ecological nature have sometimes been published, such as the data for the El Palmar and Iguazu national parks. There are data organized in grids for Lanin and Nahuel Huapi national parks, and lists of variable quality and length of birds and mammals for the majority of the parks. Nevertheless, the use of vertical and horizontal space by each species, and especially their use of space for different activities (feeding, reproduction, shelter, etc.), if often not precisely established.

METHODOLOGY

In addition to this lack of systemically organized data, financial restrictions prevent obtaining data through long expeditions involving many specialists. Therefore, and taking into account the difficulty indicated, an "ad hoc" methodology was designed, based on the ideas presented in the U.S. Fish and Wildlife Service's Habitat Evaluation Procedures.

In developing this methodology, data on vertebrate wildlife related to Rio Pilocomayo National Park were used. For the particular example summarized in this article, the data on birds and large and medium-sized mammals were used, and data on passerines (perching birds), Cricetidae (mice, rats, and voles), and bats were excluded, since the data available for the first groups are of better quality (greater reliability and precision).

Rio Pilcomayo National Park has an area of 50 000 ha and is located in the northeast part of Formosa Province. It is a highly heterogeneous component of the large chaquena prairie region, and is characterized by riverside jungles, semi-deciduous forests, savannas with palms, and swamps. Annual precipitation averages 1 300 mm, which falls mostly between October and March. Winter is the dry season. The annual mean temperature is 22°C, with a mean absolute minimum of -2°C and mean maximum of 43°C. The length of days is similar in summer and winter. The chaqueña prairies wildlife has almost no endemic species among the vertebrates, but many elements of diverse origin come together here.

The work was based on a map of components of the park, developed on the basis of satellite images and aerial photographs. The sequence of steps carried out in the development of data and obtaining results (See Table 1) was:

1. Obtaining a complete list of vertebrate species present in the National Park (based on personal observation, observations by other experts, and publications).
2. Development of a data bank, in principle using the park as an example, through the use of an NCR computer and COBOL language (the only one available at the time).
3. Rearrangement of the data through the development of two matrices for each component, one related to feeding and the other to reproduction and shelter.

The feeding matrix encompassed types of locomotion for each species, strata of vegetation from which they obtain food, and the different kinds of food consumed. This matrix was drawn up by means of generalized criteria valid for all the parks, using the parameters foods, strata, and types of locomotion (see Table 2) as theoretically possible elements that were subsequently validated. The matrix for each hierarchical component level (see: *Jerarquias del Relevamiento Ecologico de los Parques Nacionales de la Republica Argentiana* (Hierarchy of Ecological Study of the National Parks of Argentina]) includes the total number of species present, arranged by elements.

The numerical value of each element corresponds to the number of species present in it and the species together represent a wildlife guild.

Example: *Component 01.12*
Stratum: 0 m to 0.10 m
Locomotion: Swimmer - walker
Food: Grasses
Hydrochaeris hidrochaeris (capybara)

For this example, the element of the matrix has a value of aij- 1. Tables 2 and 3 present some components of the Rio Pilcomayo National Park, which were quickly surveyed in the field. Highly reliable data exist for geomorphology, soils, vegetation, and on some species of animals observed.

CONCLUSIONS

The development of a wildlife data bank and the generation of matrices based on it, permit multiple interpretations for various purposes. Some of the possible readings of these data are:

1. Diversity of guilds (elements of the matrix) for each component.
2. Detection of guilds critical for conservation (e.g., species in danger of extinction or in numerical decline can act as indicators of a particular abundance or the presence of an endemic condition).
3. Detection of species highly prejudicially affected by some type of pressure from outside the ecosystem (e.g., livestock activity, which is very common in some parts of protected areas) and impacted wildlife species or ecological groups.
4. Dominant locomotion types (morphology).
5. Dominant food types.
6. Distribution of specific resources.

Given that the data being dealt with are generalized, they have been weighted, assigning a level of reliability to the data corresponding to each species.

Given the limitations mentioned, the relationships between species and components are not definitive. This is the reason for noting the need to add to the file through field monitoring (perhaps through park wardens, experts, etc.) or through the appearance of new publications specifically about this location.

HIERARCHIES OF THE ECOLOGICAL SURVEY OF ARGENTINA NATIONAL PARKS

REGION: (1:5 000 000 to 1:1 000 000). Area characterized by a homogeneous regional climate, a particular geologic history and en demism in flora and fauna (we consider biogeographic criteria).

SUBREGION: (1:1 000 000 to 1:250 000). Area with gradients or mesoclimatic characteristic complexes in a geologically uniform frame, with characteristic modeling process and particular complexes of potential vegetation, soils, water bodies, and associated fauna.

SYSTEM: Area characterized by a pattern in landforms, soils, water bodies, and potential vegetation. They respond in a similar way to an exterior action applied in an uniform way. (Also is characterized by a recurrent process pattern).

COMPONENT: (1:1 000 000 to 1:125 000). Area relatively uniform in topography, soils, vegetation, and fauna.

PHASE: Subdivision or sector of the component or system, with uniformity in soils and vegetation associated to characteristics with importance agrostems or created by human action (human erosion, cultivation, burned areas, etc.).

Table 1: Sequence of steps carried out in the development of data and obtaining results.

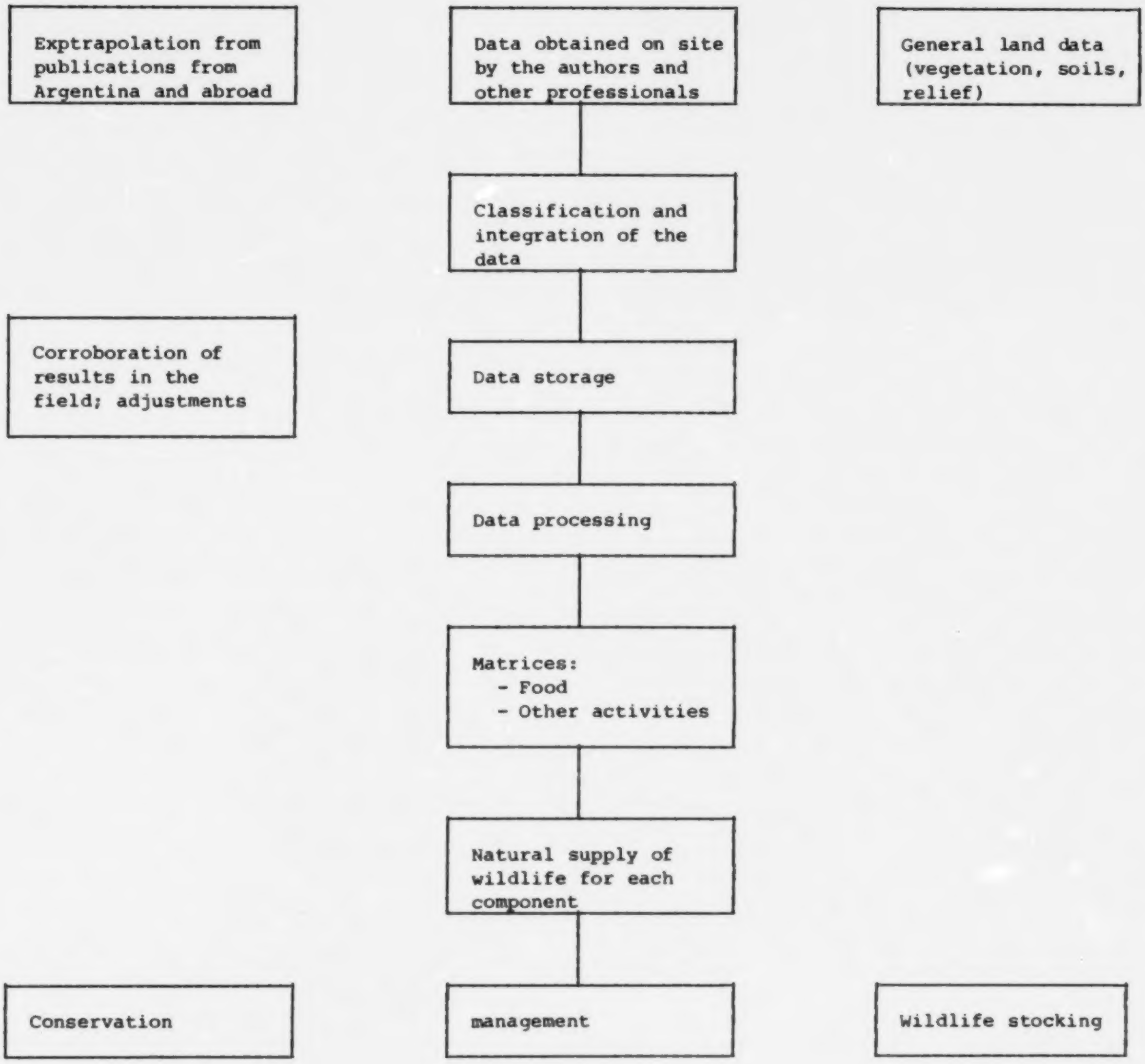
Exptrapolation from publications from Argentina and abroad
Data obtained on site by the authors and other professionals
General land data (vegetation, soils, relief)
Classification and integration of the data
Corroboration of results in the field; adjustments
Data storage
Data processing
Matrices:
- Food
- Other activities
Natural supply of wildlife for each component
Conservation
management
Wildlife stocking

Table 2: Food/location matrix of the Rio Pilcomayo National Park[1].

Food / **Strata** **Locomotion**	Algae	Grasses	Shoots	Roots	Flowers	Nectar	Seeds	Fruit	Honey	Crabs	Clams	Fish	Insect eggs
Aquatic bottom													
swimmer-walker													
Shallow water													
walker													
walker-flyer													
flyer-percher													
flyer-percher-walker													
Deep water													
walker-flyer													
swimmer-walker													
flyer-percher													
Floating													
walker													
walker-flyer													
swimmer-walker-flyer													
Sub-surface													
walker													
walker-flyer													
walker-climber													
From 0 to 0.10 m													
walker													
walker-flyer													
walker-climber													
walker-flyer-climber													
climber-flyer													
swimmer-walker													
From 0.10 to 1.50 m.													
walker-flyer													
walker-climber													
walker-flyer-climber													
climber-flyer													
flyer													
flyer-percher													

Species - 142[2]

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[1] Portion of the original table for example purposes.

[2] Total number of species present in the whole park.

Table 3: Wildlife species corresponding to guilds in the food-locomotion matrix.

Stratum	Locomotion	Food	Genus/species	Common name
Shallow water	Walker	Grasses	*Blastocerus dichotomus*	Marsh deer
			Mazama gouazoubira	Grey brocket
		Crabs and shrimp	*Cerdocyon thous*	Crab-eating fox
			Chrysocyon Brachyurus	Maned wolf
		Clams and aquatic snails	*Chrysocyon Brachyurus*	Maned wolf
		Other aquatic invertebrates	*Chrysocyon brachyurus*	Maned wolf
		Fish and tadpoles	*Cerdocyon thous*	Crab-eating fox
			Chrysocyon brachyurus	Maned wolf
		Amphibians and reptiles	*Cerdocyon thous*	Crab-eating fox
			Chrysocyon brachyurus	Maned wolf
		Birds and small mammals	*Cerdocyon thous*	Crab-eating fox
			Chrysocyon brachyurus	Maned wolf
	Walker-flyer	Seeds	*Plegadis chihi*	White-faced glossy ibis
		Crabs and shrimp	*Ciconia maguari*	Maguari stork
		Clams and aquatic snails	*Himantopus melanurus*	Southern stilt
			Tringa flavipes	Yellowshank sandpiper
			Tringa solitaria	Solitary sandpiper
		Other aquatic invertebrates	*Ciconia maguari*	Maguari stork
			Plegadis chihi	White-faced glossy ibis
			Himantopus melanurus	Southern stilt
			Tringa flavipes	Yellowshank sandpiper
			Tranga solitaria	Solitary sandpiper
			Gallinago gallinago	Common snipe
		Fish and tadpoles	*Ciconia maguari*	Maguari stork
		Amphibians and reptiles	*Ciconia maguari*	Maguari stork
		Birds and small mammals	*Ciconia maguari*	Maguari stork
	Walker-climber	Grasses	*Procyon cancrivorus*	Crab-eating
		Crabs and shrimp	*Lutreolina crassicaudata*	Thick-tailed opossum
			Procyon cancrivorus	Crab-eating raccoon

MANUAL OF GUIDELINES FOR THE INTEGRATION OF WILDLIFE RESOURCE ASSESSMENT WITH ECOLOGICAL LAND SURVEYS

MANUEL DE LIGNES DIRECTRICES POUR L'INTÉGRATION DE L'ÉVALUATION DES RESSOURCES FAUNIQUES AVEC LES RELEVÉS ÉCOLOGIQUES DU TERRITOIRE

INTRODUCTORY COMMENTS ON THE DRAFT GUIDELINES MANUAL

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EARLY DEVELOPMENT

Initial suggestions for some type of reference document or guidelines manual were expressed at Land/Wildlife Integration Workshop #2, held at Banff, Alberta in March, 1982. The particular need identified at that time was for a document that provided clear and comprehensive guidelines on what an ecological land survey (ELS) is and how it can or should be conducted. Interest was also expressed regarding how ELS techniques could be employed in conducting wildlife resource inventories and evaluations. A third major point of interest and concern was the need to prepare client-oriented (user-friendly) inventory products and it was felt that a guidelines manual could address this subject as well.

Following the Banff workshop, I conducted a telephone poll of several Wildlife Working Group (WWG) members to determine the level of support for a potential guidelines manual and to obtain further ideas on content and orientation. Most individuals supported the general concept, although some were sceptical about the potential usefulness and feasibility of attempting such a project.

Initial terms of reference for a guidelines manual were distributed in WWG newsletter #4 (June/82) and a brief outline and draft introduction section were included in newsletter #5 (March/83). WWG members were invited to participate in drafting sections of the proposed manual that particularly interested them. A small core of individuals, primarily Gary Ironside, Pat Beaulieu, Shirley Nelson, and myself, contributed written ideas and material based on the initial brief outline. Tom Hoekstra, with the U.S. Forest Service in Fort Collins, also became aware of this project and offered to contribute ideas that he and his colleagues had been developing on the relevance of ecological theory to wildlife resource assessment. From these materials, a detailed 30-page outline was prepared with some content included in point form. This was finalized in March, 1984.

The detailed outline sat largely untouched for the next year, except for the comprehensive written paper which was prepared by Tom Hoekstra, Curtis Flather, and Gary Ironside (September/84) entitled, "Theoretical Basis for Integrating Wildlife Resources in Ecological Land Surveys." This paper is intended to provide the basis for Chapter 3 of the guidelines manual.

CURRENT STATUS

With the third Land/Wildlife Integration Workshop aproaching, pressure mounted to develop first drafts of the core sections of the manual so that meaningful review and discussion could be obtained from a broader cross-section of Wildlife Working Group members. John Kansas was contracted to further flesh out this document to the form that it is in now.

The table of contents for the manual, as developed to date, is shown in Table 1. Highlights of Chapters 3, 4, and 5 are presented elsewhere in these proceedings. The introduction to the manual currently reads:

INTRODUCTION

1.1 Background Preamble

Numerous individuals working in the field of wildlife resource management and ecological land survey (ELS) have expressed the need for a reference manual that provides some guidance for the collection, synthesis, and presentation of wildlife resource information within an ecological land-based framework. There are many problems to be addressed and limitations to be recognized in attempting to present useful information on complex biological phenomena in the form of simplistic classification regimes, evaluation products, and cartographic displays. What type and quantity of field data should be collected? What kind of classification regimes and mapping formats are most useful?

Table 1: Table of Contents for August/85 Draft of "Guidelines for the Integration of Wildlife Resource Assessment with Ecological Land Surveys".

1. INTRODUCTION
   1.1 Background Preamble
   1.2 Purpose and Objectives

2. THE RELEVANCE OF INFORMATION SYSTEM MODELS

3. THEORETICAL BASIS FOR INTEGRATING WILDLIFE RESOURCES IN ECOLOGICAL LAND SURVEYS
   3.1 General
   3.2 Niche Theory
   3.3 Island Biogeography Theory
   3.4 Succession Theory
   3.5 Hierarchy Theory

4. INCORPORATING WILDLIFE RESOURCE VALUES INTO ECOLOGICAL LAND SURVEYS

   4.1 General
   4.2 The Wildlife Component of the ELS Proposal
   4.3 The Wildlife Component of the Ecological Land Classification
   4.4 The Wildlife Component of the Ecological Land Evaluation
   4.5 Survey Products - Meeting the Land Use Planner's Needs
   4.6 Literature Cited

5. USING LAND/WILDLIFE RELATIONSHIP MODELS AND ECOLOGICAL LAND SURVEYS TO AID THE EVALUATION OF WILDLIFE RESOURCES
   5.1 Wildlife Resource Evaluation
   5.2 Land/Wildlife Relationship Models
   5.3 Selecting the Best Land Attributes as Measures of Wildlife Habitat Quality
   5.4 Ecological Land Survey as a Tool for Assessing Wildlife Resource Values
   5.5 Evaluation Products - Meeting the Wildlife Manager's Needs
   5.6 Literature Cited

6. INFORMATION SUPPORT TECHNOLOGIES
   6.1 Computerized Land Resource Data Systems
   6.2 Satellite Data and Image Analysis

7. ACHIEVING COOPERATION IN DATA COLLECTION AND INFORMATION FLOW

8. GLOSSARY OF SELECTED TERMS AND DEFINITIONS

9. PRIMARY SOURCES FOR WILDLIFE RESOURCE AND ECOLOGICAL LAND SURVEY INFORMATION

How do we evaluate wildlife resources accurately and consistently? How do we use wildlife characteristics in delineating and defining ecological land units? Some general guidelines may be possible; however, the specific answers to these questions will vary depending upon the particular objectives of a study.

The Wildlife Working Group (WWG) of the Canada Committee on Ecological Land Classification (CCELC) is well suited to addressing this need for a reference manual, as it represents the thoughts and interests of approximately 100 individuals from all regions of Canada and with backgrounds in either wildlife resource management and assessment or ecological land survey, if not both. The stated goal of this Working Group is: "To encourage and facilitate the development of effective and standardized methodologies for wildlife habitat classification and evaluation, as well as to further the integration of wildlife values within an ecological land survey framework".

1.2 Purpose and Objectives

The field of ecological land survey and its relevance to wildlife management is very broad and newly developing. This manual is designed to provide guidance to individuals who want to conduct wildlife resource surveys and evaluations in an ecological land-based context, as well as those who wish to conduct ecological land surveys which recognize and incorporate wildlife resource values. This manual aims at bringing together the collective thinking of WWG members, to outline the current "state of the art", and to provide a basic framework for detailing methodologies to meet specific needs. This framework will hopefully foster more rigorous, objective, and comparable land surveys and resource assessments which address the information needs and application requirements of the wildlife resource management field. The manual should facilitate a more effective application of land-based wildlife information by resource planners and managers.

In brief, the purpose and objectives of this manual can be stated as:

Purpose:

To provide a working framework (guidelines) for integrating wildlife resource inventory and assessment with ecological land survey, as well as to enhance the presentation of inventory information to client groups.

Objectives

1. To provide a basic understanding of the relevance of information systems theory and ecological theory to wildlife resource assessment and ELS.
2. To outline practical techniques and considerations for incorporating wildlife resource values into ecological land surveys.
3. To outline practical techniques and considerations for using ecological land surveys to aid the evaluation of wildlife resources.
4. To outline the opportunities and advantages of using modern technological advances, such as satellite imagery, computer graphics, and data base management, in resource inventory and assessment.
5. To provide suggestions and sources to aid data collection and information sharing in general.

WORK TO BE DONE

The main purpose of this session of the Mont Ste-Marie meeting was to further broaden the input required to make this guidelines manual truly useful. Without critical and constructive review and comment, this document will not adequately achieve the objectives that we set for it. A number of presentations briefly introduced several of the topics covered by selected sections of the manual as a basis for stimulating the discussion group sessions.

The recommendations of each discussion group were to be considered in developing further drafts of the guidelines manual. More formal responsibilities will be assigned to editors, authors, and reviewers of various sections of the manual to ensure that further progress and the eventual completion of the manual are realized.

COMMENTAIRES D'INTRODUCTION SUR LA VERSION PROVISOIRE DU MANUEL DE LIGNES DIRECTRICES

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DÉBUTS

Les premières propositions relatives à un certain type d'ouvrage de référence ou à un manuel de lignes directrices ont été exprimées lors du 2e atelier sur l'intégration terre/faune, qui s'est tenu à Banff (Alberta) en mars 1982. À cette époque, on a identifié le besoin particulier de rédiger un document fournissant des lignes directrices claires et détaillées sur la nature d'un relevé écologique du territoire (RET) et sur la façon de l'effectuer. On s'est également intéressé à la façon d'employer les techniques RET au cours de l'inventaire et de l'évaluation des ressources fauniques. La nécessité de préparer des produits axés sur la clientèle (d'accès facile) constitue un troisième important point d'intérêt et de préoccupation, qui, estime-t-on, pourrait être traité dans un manuel de lignes directrices.

Après l'atelier de Banff, j'ai téléphoné à plusieurs membres du Groupe de travail sur la faune, afin de connaître le nombre de personnes susceptibles de collaborer à la préparation d'un tel manuel et de recueillir d'autres points de vue sur son contenu et son orientation. La plupart des personnes étaient d'accord avec l'idée générale, même si certaines se sont montrées sceptiques quant à l'utilité potentielle et à la faisabilité d'un tel projet.

Le but initial d'un manuel de lignes directrices a été décrit dans le bulletin n°4 (juin 82) du Groupe de travail sur la faune, tandis que le bulletin n°5 (mars 83) contenait un bref aperçu et une section sur un projet d'introduction. Les membres du Groupe de travail sur la faune ont été invités à participer à la rédaction préliminaire de sections portant sur des sujets qui les intéressent de façon particulière. Composant un petit groupe de personnes, Gary Ironside, Pat Beaulieu, Shirley Nelson et moi-même avons présenté par écrit des idées et des données basées sur le bref aperçu initial.

De plus, Tom Hoekstra du "U.S. Forest Service" de Fort Collins, qui avait entendu parler de ce projet, a offert de nous communiquer les idées que lui-même et ses collègues ont élaborées sur l'applicabilité d'une théorie écologique à l'évaluation des ressources fauniques. À partir de tout cela, on a préparé un exposé détaillé de 30 pages où certaines données sont présentées en abrégé. Ce travail a été terminé en mars 1984.

L'exposé détaillé n'a pratiquement pas été modifié au cours de l'année suivante, à l'exception du rapport détaillé rédigé par Tom Hoekstra, Curtis Flather et Gary Ironside (septembre 84), intitulé "Theoretical basis for integrating wildlife resources in ecological land surveys". On compte baser le chapitre 3 du manuel de lignes directrices sur ce rapport.

SITUATION ACTUELLE

À mesure qu'approchait la date d'ouverture du 3e atelier sur l'intégration terre-faune, on se mit à travailler fébrilement à la rédaction de la première version des sections de base du manuel, que l'on comptait faire examiner et étudier par un plus grand nombre de membres du Groupe de travail sur la faune. John Kansas a été chargé, en vertu d'un contrat, d'étoffer ce document; il lui a donné la forme que nous lui connaissons aujourd'hui.

La table des matières, dans sa forme actuelle, figure au tableau 1. Les points saillants des chapitres 3, 4 et 5 seront présentés par les conférenciers nommés plus loin. Voici le texte actuel de l'introduction du manuel de lignes directrices.

1. INTRODUCTION

1.1 Préambule

Bon nombre de personnes qui travaillent dans le domaine de la gestion des ressources fauniques et des relevés écologiques du territoire (RET) ont exprimé le besoin d'un ouvrage de référence renfermant certaines lignes directrices sur la collecte, la synthèse et la présentation de données sur les ressources fauniques, dans un cadre écologique. Il faut résoudre de nombreux problèmes et connaître les limitations lorsqu'on tente de présenter des données utiles sur des phénomènes biologiques complexes, sous forme de systèmes de classification simplifiés, de produits d'évaluation et de présentations cartographiques. Quel type de données sur le terrain faut-il recueillir et combien? Quels sont les systèmes de classification et les formats cartographiques les plus utiles? Quelle est la façon d'évaluer précisément et uniformément les ressources fauniques? Comment doit-on utiliser les caractéristiques fauniques pour délimiter et définir les unités terrestres écologiques? Il est peut-être possible d'appliquer certaines lignes directrices générales, mais les réponses spécifiques à ces questions varient selon les objectifs particuliers d'une étude.

Tableau 1 **:**

Table des matières de la version provisoire (août 1985) des lignes directrices relatives à l'intégration de l'évaluation des ressources fauniques aux relevés écologiques du territoire.

1. INTRODUCTION
    1.1 Préambule
    1.2 But et objectifs

2. PERTINENCE DES MODÈLES DE SYSTÈMES D'INFORMATION

3. BASE THÉORIQUE DE L'INTÉGRATION DES RESSOURCES FAUNIQUES AUX RELEVÉS ÉCOLOGIQUES DU TERRITOIRE
    3.1 Généralités
    3.2 Théorie de la niche
    3.3 Théorie de la biogéographie des îles
    3.4 Théorie de la succession
    3.5 Théorie de la hiérarchie

4. INTÉGRATION DES PARAMÈTRES FAUNIQUES AUX RELEVÉS ÉCOLOGIQUES DU TERRITOIRE
    4.1 Généralités
    4.2 Composante faunique de la proposition relative aux RET
    4.3 Composante faunique de la classification écologique du territoire
    4.4 Composante faunique de l'évaluation écologique du territoire
    4.5 Résultats des relevés - Satisfaire les besoins des planificateurs de l'utilisation des terres
    4.6 Références citées

5. UTILISATION DE MODÈLES DE RELATION TERRE/FAUNE ET DE RELEVÉSÉCOLOGIQUES DU TERRITOIRE POUR FACILITER L'ÉVALUATION DES RESSOURCES FAUNIQUES
    5.1 Évaluation des ressources fauniques
    5.2 Modèles de relation terre/faune
    5.3 Choix des meilleurs attributs des terres comme mesures de la qualité des habitats fauniques
    5.4 Le relevé écologique du territoire : un moyen d'évaluer les paramètres fauniques
    5.5 Résultats de l'évaluation - Satisfaire les besoins des gestionnaires de la faune
    5.6 Références citées

6. TECHNIQUES DE SUPPORT DE L'INFORMATION
    6.1 Systèmes informatisés de données sur les ressources des terres
    6.2 Données recueillies par satellite et analyse des images

7. COOPÉRATION DANS LA COLLECTE DES DONNÉES ET LA DIFFUSION DES INFORMATIONS

8. GLOSSAIRE DE TERMES ET DÉFINITIONS

9. PRINCIPALES SOURCES DE DONNÉES SUR LES RESSOURCES FAUNIQUES ET LES RELEVÉS ÉCOLOGIQUES DU TERRITOIRE PAR PROVINCE ET PAR TERRITOIRE AU CANADA

Le Groupe de travail sur la faune du Comité canadien de la classification écologique du territoire (CCCET) est bien placé pour répondre à ce besoin, car il représente les opinions et les intérêts d'environ 100 personnes de toutes les régions du Canada, spécialisées en gestion et en évaluation des ressources fauniques ou en relevé écologique du territoire, ou encore dans ces deux domaines. L'objectif de ce groupe de travail est "d'encourager et de faciliter la mise au point de méthodes uniformisées et efficaces de classification et d'évaluation des habitats fauniques, et de poursuivre l'intégration des paramètres fauniques dans le cadre d'un programme de relevé écologique du territoire".

1.2 But et objectifs

Les relevés écologiques du territoire et leur application à la gestion de la faune constituent un domaine très vaste et tout nouveau. Le présent manuel a pour but d'aider les personnes désireuses d'effectuer des relevés et des évaluations de ressources fauniques dans un cadre écologique, et celles qui veulent effectuer des relevés écologiques du territoire reconnaissant et intégrant des paramètres relatifs aux ressources fauniques. Ce manuel a pour but de réunir l'opinion de tous les membres du Groupe de travail sur la faune en vue d'exposer l'état actuel des connaissances et de fournir un cadre à partir duquel on pourra élaborer des méthodes plus détaillées pour répondre à des besoins spécifiques. Ce cadre favorisera, nous l'espérons, l'obtention de relevés du territoire et d'évaluation de ressources plus rigoureux, plus objectifs et plus comparables, qui traitent en particulier des besoins en matière d'information et des exigences relatives à l'application dans le domaine de la gestion des ressources fauniques. Ce manuel devrait aussi faciliter l'application plus efficace des données écologiques sur la faune par les planificateurs et les gestionnaires des ressources.

On peut résumer de la façon suivante le but et les objectifs d'un tel manuel:

But :

Fournir un cadre de travail (lignes directrices) permettant d'intégrer l'inventaire et l'évaluation des ressources fauniques aux relevés écologiques du territoire, et améliorer la présentation de données relatives à l'inventaire à des groupes de clients.

Objectifs :

1. Fournir des connaissances de base sur l'applicabilité de la théorie des systèmes de données et de la théorie écologique à l'évaluation des ressources fauniques et aux RET.
2. Exposer les techniques et les aspects pratiques permettant d'intégrer les paramètres fauniques aux RET.
3. Exposer les techniques et les aspects pratiques permettant d'utiliser les RET pour faciliter l'évaluation des ressources fauniques.
4. Exposer les occasions et les avantages d'utiliser les techniques les plus récentes, comme les images obtenues par satellite, les graphiques informatiques et la gestion de bases de données, pour inventorier et évaluer les ressources.
5. Formuler des propositions et fournir des sources de données dans le but de faciliter la collecte et le partage des données en général.

ACTIVITÉS À VENIR

Cette séance de la réunion avait pour but d'accroître encore plus les apports nécessaires pour faire de ce manuel de lignes directrices un ouvrage véritablement utile. Sans une analyse et des commentaires critiques et constructifs, ce document ne remplira pas complètement tous les objectifs qui lui ont été fixés. Les textes ci-après exposent brièvement plusieurs sujets traités dans certaines sections du manuel. Les nouvelles versions tiendront compte des recommandations de chaque groupe de discussion de la réunion. Il faudra attribuer aux rédacteurs, aux auteurs et aux réviseurs des responsabilités plus officielles si l'on veut faire progresser jusqu'au bout la préparation du manuel.

INCORPORATING WILDLIFE RESOURCE VALUES INTO ECOLOGICAL LAND SURVEYS

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OVERVIEW

Definition of Ecological Land Survey

Ecological Land Survey (ELS) is an interdisciplinary approach to the gathering and interpretation of environmental data. Under this approach, the environment is considered to be comprised of natural or man-modified ecosystems which are land based. In an ELS context, land is referred to in the holistic sense as being composed of a complex and interconnected web of abiotic and biotic ecological components, including bedrock, landforms, soils, water, climate, vegetation, and wildlife.

Rationale of ELS

The increasingly complex fields of natural resource management and land use planning necessitate a system of land survey that promotes a comprehensive understanding of landscape areas as dynamic ecosystems comprised of interrelated physical and biological components. The use of a particular land resource often has potential to simultaneously impact other land resources. In recent years, this simple premise has been increasingly recognized and confronted by resource management and land use planning agencies. Such terms as "integrated management planning" and "multiple use" attest to this recognition. Effective management and planning within an integrated management forum demand a system or framework for resource data and information. ELS is a means of simplifying and organizing a very diverse body of land-related data in a way that allows one to address very complex issues, for long-term planning and day-to-day management.

The interdisciplinary approach of ELS has many practical advantages over conducting several uni-disciplinary surveys:

1) An integrated approach reduces redundant data gathering. As such, resources normally spent on the duplication of what others have done can be redirected to enhance the baseline study.

2) The more stable aspects of the environment are stressed in the data collection phase so as to maintain the usefulness of the baseline study over the long term.

3) A team approach to data collection avoids the proliferation of discordant map lines for and descriptions of areas having similar environments.

4) The data base is broad and flexible and can be used to assess and predict interactions between disciplines.

5) The report(s) and map(s) are amassed into one convenient package for reference and access.

6) The environmental data are simplified into one common framework.

7) The costs/benefits of a single interdisciplinary survey outweigh the cumulative costs/benefits of a number of uni-disciplinary surveys.

8) Collection of a single data base at a given time sets the framework for meaningful monitoring and comparison of changes in the various components over time; this would be very difficult if there were large time gaps between data collection for the various components.

9) The interactive nature of ELS should facilitate a more equitable and even weighting of the relative importance of specific disciplines through the planning and decision-making process.

General Methods of ELS

The basic ELS consists of three major steps.

1) Survey Proposal

This first step consists of interaction and discussion between the surveyors and the survey proponents/users. The primary objective is to set study goals and terms of reference in such a way that the perceived needs of the users can be effectively and realistically met. This includes:

1) identifying user needs, work to be done, and desired end products;
2) assessing the mandate and purpose of the work;
3) establishing the constraints of the survey (i.e. available time, money, and manpower);
4) setting goals to ensure that the detail, timeliness, and scope of the ecological data are appropriate to the user; and
5) developing an integrated survey and selecting a team leader.

At this step of the survey, a representative of each resource discipline to be considered must provide input concerning integration requirements. Dialogue at this early step often sets the template for the remainder of the survey.

2) Ecological Land Classification

This is the data-gathering step of the ELS. The study area is partitioned into areas of similar environment and the units are classified based on physical and biological characteristics. As it would be impossible to collect all possible forms of land data, the techniques used rely on the rapid identification and analysis of sets of data that are useful for many purposes and are "keys" in the framework of land ecosystems. This is achieved via remote sensing analysis (usually using color Landsat images and black-and-white aerial photographs) combined with field checking of variable intensity.

Remote sensing or "image analysis" yields the preliminary data sets on the physical and biological characteristics of the land and initially subdivides the study area into "ecologically significant" map units (Walmsley et al. 1980). The remote sensing analysis is supplemented and refined, prior to field checking, through a review of available literature relevant to the study area. The subsequent field checking verifies the accuracy of the original map unit delineations and provides certain forms of data (e.g. soil, vegetation, and wildlife) which are not readily attainable by in-office techiniques. Map unit boundaries are often modified subsequent to field checking.

The number, size, and descriptive detail of map units within a study area may vary according to the needs of users. The ELS aproach has accommodated this variation through the evolution of a hierachical system of classification and mapping. Table 1 presents an overview of the various levels of generalization within this hierarchy, and some common benchmarks for their recognition. Generally, as one descends through the hierarchy, map units become smaller, the variability in characteristics decreases, and the descriptive data become increasingly specific. Associated with changes in mapping scale are also changes with respect to the utility of ELS to resource managers and land use planners. The following list indicates broad orders of resource management and land use planning within a basic hierarchical framework of ELS.

Hierarchy	Orders of Resource Management and Land Use Planning
Ecozone	National, International
Ecoprovince	National, Provincial
Ecoregion	Regional, Sub-Provincial
Ecodistrict	Sub-regional
Ecosection	Community
Ecosite	Detailed
Ecolement	Site-specific

(from Wiken 1980)

The level of detail used to characterize map units in the Ecological Land Classification depends on the scale of mapping and the size of the map unit. Classification requires data collection and/or organization that promote(s) description of the following:

1) Components present - The six major components to be examined include terrain (landforms, bedrock geology, surficial materials), soils, hydrology, climate, vegetation, and wildlife.

2) Relationships of components - Climate/vegetative composition, snow depth/wildlife population, soil type/plant succession, and stream width/fish abundance are examples of the types of relationships that may be used to describe a map unit. Each map unit should express certain relationships which can be used to classify that map unit.

3) Abundance - This refers to the relative quantities or percentages of land attributes associated with each map unit. Examples would be the relative percentage cover of each major vegetation grouping, plant biomass production per unit area, volumes of stream runoff, concentration of available soil nutrients, and wildlife or fish populations.

4) Pattern - This refers to the arrangement of components in either the vertical or horizontal plane. For vegetation, it could include the distribution of species in a spatial sense, their structure, and their physiognomy. For wildlife, it could refer to broad geographic and elevational preferences or to patterns of use of layers of vegetation within a particular cover type. As is true for all four types of ecosystem descriptor, their detail depends on the scale of mapping and the size of the map unit.

The final activity of the Ecological Land Classification is to present the collected data in map, textual, tabular, and/or computer format. The exact presentation format to be implemented depends on the needs of the user and should be specified during the survey proposal step.

3) Ecological Land Evaluation

Once the ecological data have been collected, organized, and presented, they can be evaluated. Ecological land evaluations include interpretations (e.g. land capability, land suitability, environmental impact assessment, sensitivity, etc.) and prescriptive plans and management schemes for various land uses.

Data can be extracted or retrieved via single or multiple descriptive characteristics, or by total systems. As a result, an ecological land data base is extremely flexible for many purposes. It allows the production of thematic (single factor) maps, such as the location of potential gravel deposits, areas close to bedrock, or sites having a high percentage of sedge cover. Multiple factor maps or tabulations can also be extracted. A user may wish, for example, to know of all map units having a combination of characteristics, such as an open lodgepole pine-pinegrass communities, mixed relief, and small lakes (as potential sites for campgrounds). Alternatively, knowing that a particular map unit provides excellent wintering habitat for moose, a wildlife manager may wish to know the extent and location of similar sites within his management area.

Finally, ELS is based on ecosystem relationships. It therefore allows users to predict ecosystem response. For example, map units of a particular "class" often occur predictably in juxtaposition with certain other map units. Thus, if a particular map unit were being considered for resource development, its impact on surrounding ecosystems could be predicted.

General Considerations for Incorporation of a Wildlife Component

Until recently, the wildlife resource has received little in the way of serious attention as a major component of ELS. Many past resource surveys or inventories have either ignored wildlife completely or have incorporated wildlife as an add-on, subsequent to the completion of the classification step of the survey. The hydrological and climatic components have also received limited representation from land classifications that have traditionally emphasized soils, landforms, and vegetation (Stelfox 1983). However, a general recognition of the need for a more holistic approach to land management has led to an increased integration of hydrologic, climatic, and wildlife values.

The wildlife resource has been difficult to address in the context of ELS for the following reasons:

1) Many wildlife species are highly mobile and use a wide range of landscapes.
2) Wildlife populations and their use of areas of land can fluctuate widely over time.
3) Wildlife are relatively difficult to observe, particularly with remote sensing techniques.
4) A high percentage of past wildlife research has avoided habitat-based assessments; thus, relatively little was known of wildlife use as a function of landscape ecosystems.

Rationale for Incorporating Wildlife Values into ELSs

ELS provides an excellent framework for collecting and interpreting wildlife data, while at the same time providing a geographic (spatial) data or information base that can facilitate more intelligent and objective land use planning and resource management decisions. Regardless of some of the problems mentioned above, most wildlife species can be effectively correlated with physical and biological attributes of the land. These attributes are also meaningful to other resource interests, such as forestry, agriculture, and mineral extraction (Stelfox 1983). By considering wildlife as a component of a land ecosystem, we establish a direct management link between wildlife and the land. The advantages of using ELS as a basis for identifying wildlife resource values are discussed in more detail later in this paper. Finally, in the last decade or so, there has been an increased emphasis on research into wildlife/habitat interactions. As this data base continues to grow, so will the incorporation of the wildlife component into

ELS.

The next two obvious questions are: (a) When, or at what phase of the ELS, does the wildlife component warrant incorporation? (b) How, or in what manner, should wildlife values be incorporated into ELS? These two questions can best be answered within the context of the three major steps of an ELS:

1) Survey Proposal - Effective integraion of wildlife requires its consideration at the earliest stage in the development of survey proposal during the establishment of study objectives.
2) Ecological Land Classification - Wildlife data should be incorporated as part of the ecological land classification and mapping base. Such wildlife data may be treated as "diagnostic" or "characteristic" attributes of the map unit polygons.
3) Ecological Land Evaluation - Wildlife resource interpretations or assessments should be considered in the evaluation step of the ELS. "Raw" ELC attribute data can be converted into evaluations that can be more effectively used in resource management and land use planning.

The following three sections discuss in more detail techniques, logistics, and concerns associated with incorporating the wildlife component into each of these steps.

THE WILDLIFE COMPONENT OF THE SURVEY PROPOSAL

As the ELS process has evolved and wildlife has become an increasingly represented component, it has become apparent that there must be input from wildlife personnel at the earliest stages of planning. Wildlife managers (Holroyd 1980, Prescott 1980) and resource planners (Seel 1982) alike have recognized and expressed this need. Some advantages of early representation of the wildlife component (i.e., during the survey proposal step) are:

1) Early representation sets up a base of communication between the scientists associated with the various components of the ELS. Ideally, this could extend throughout the entire process. Seel (1982) noted that the ELS process forces "... a group of scientists working within the roles of the system even prior to any actual field work, to develop a consensus on the philosophical, methodological and technological parameters which will guide their collective efforts." This sort of communication can only serve to aid the cause of the wildlife resource and, more importantly, the land resource as a whole.
2) Early discussion ensures that the client's wildlife-related study objectives can be realistically met by the wildlife study team. Specific considerations should include scope, detail, time frame, and phasing of the study.
3) It ensures that there will be a logical and feasible succession or progression between the data collection, evaluation, and survey end-products (i.e., it is important to know, early in the study, that the types and detail of data collected can be evaluated in such a way that the client's desired end products are achieved).
4) Early discussion between members of the integrated resource team provides each member with an idea of the specific logistics and limitations of the other's survey procedures. Thus, effective compromises can be reached to best serve the land resource as a whole. As wildlife are a mobile resource, with seasonal land preferences that often must be measured using specialized and "timely" (e.g., winter aerial surveys) procedures, it is especially important that this be communicated to both the client and the other members of the integrated team.
5) By considering wildlife values at the survey proposal step, it serves to ensure that wildlife is treated as an integral land component, rather than simply a user of land.

Prior to setting the terms of reference of the survey, it is imperative that the client seek wildlife expertise to ensure that the level of detail, the scope of the subject matter being examined, and the time frames and phasing of data collection will meet their wildlife-related data and information needs. Some examples of the kinds of detailed considerations that should be made prior to finalizing the terms of reference are:

1) Selection of "featured" or "indicator" species

It is rare for wildlife managers or planners to be alloted the time and/or money to monitor population trends and population viability for most or all the wildlife species in their study area (and especially so within a broad definition of wildlife). Therefore, it is usually necessary to select a group of species that will serve as indicators of the diversity and population viability of species with similar habitat requirements. In the United States, these have been termed "management indicator species" (Harcombe 1984). The indicator species chosen should reflect the management and/or planning concerns of the client. Management indicator species may be chosen from one or more of the following categories (from Harcombe

1984):

a) Endangered and threatened wildlife species identified for the planning or management area (recovery species);
b) Species with special habitat needs that may be influenced significantly by planned management programs (specific habitat indicators);
c) Species commonly hunted, fished, or trapped (featured species);
d) Nongame species of special interest (featured species);
e) Additional wildlife species selected because their population changes are believed to indicate the effects of management activities on other species of selected major biological communities (ecological indicators).

The final selection of wildlife species for incorporation into the ELS is up to the client. However, it has been suggested that the minimum number of wildlife species chosen be dictated by three mandatory criteria (Salwasser and Unkel 1981):

a) All listed threatened and endangered species;
b) All sensitive species whose populations or habitats are measurable and will be affected by anticipated vegetative manipulation; and
c) Significant harvest species and highly valued non-consumptive species identified in planning issues.

Other criteria outlined by Salwasser and Unkel (1981) that may be considered are:

a) Species with specific habitat needs that may be affected by planned management programs;
b) Species whose populations indicate the welfare of other species that are important in forest management;
c) Species that depend on early successional vegetation; and
d) Species that depend on late succesional vegetation.

2) Types of wildlife data required

The categories of wildlife data requested to be collected in the terms of reference (e.g., habitat use vs. population vs. behavior) should "match" the specific type(s) of resource evaluation intended. The following examples should illustrate the point:

- If the client were primarily interested in obtaining a basic indication of the relative importance of the various land units to wildlife species or species groups for regional planning purposes, then it would be inappropriate to collect precise population data.
- If the client were concerned with the inherent habitat capability rather than the current habitat suitability of land units (perhaps in an area undergoing intensive current or planned resource extraction), then such disturbance and mortality factors as wildfire and cattle grazing would not be considered in the data collection process (since these "manageable" factors are not considered to have an effect on the long-term capability of the habitat to support wildlife - Demarchi et al. 1983).

3) Level of survey detail

The client should be aware of the appropriate degree of sampling intensity required to achieve the desired level of survey accuracy or reliability. For example, a large-scale ELS is requested of a proposed wildland recreation/interpretive site. Along with the need for soils and vegetation data, for selection of campground and trail locations, there is a request to accurately determine breeding bird diversity indices for each map unit (to aid in the choice of an optimally located interpretive "birding" trail). In this situation, a literature review and one or two days of cursory bird counts would not suffice. Rather, the client should be aware of the need for a systematic, intensive breeding bird call count survey of two to three months duration - one that ensures an even and sufficient sampling effort over the range of map units present. On the other hand, if breeding birds were being considered as just one of a half dozen species groupings for an overall habitat capability rating, then a single reconnaissance survey, in combination with a literature review and subjective evaluation by a breeding bird expert, may suffice.

4) Survey time frame

Holroyd (1980) suggested that a wildlife survey should be conducted for two or more years to allow for unusual weather and wildlife distributions. Ideally, this is a valid suggestion, and is especially relevant in the case of an assessment of the current habitat suitability for ungulates, which can exhibit markedly different habitat use patterns during harsh versus mild winters. However, the funding reality and time-frame limitations often require an ELS to be conducted in less than one full year. This is particularly true for large-scale surveys of a small area (e.g., when ELS is used to assess environmental impacts of a proposed resource development site). Hence, the client should seek advice as to the most suitable phasing of field data collection (i.e., the optimal season of field data collection given the objectives of the ELS) or as to whether a single season of field study will fully satisfy the objectives of the survey. To answer these questions, the particular applications and limitations of the various field data collection procedures must be understood. For example, an oil company is planning to link producing oil wells for a pipeline placement pattern. The regional wildlife managers' primary concerns are for moose and furbearers, since the area is hunted heavily and encompasses two registered traplines. Budget constraints limit the field survey to four months, but the choice of season is flexible. In this situation, winter sampling by track counts and aerial surveying would allow objective data collection for both moose (pellet counts/browse surveys), but not for furbearers. Thus, the client must discuss these types of phasing considerations with a wildlife biologist before the terms of reference are drawn up. Failure to do so may lead to compromises - for the wildlife consultant conducting the survey and, more importantly, of the wildlife resource.

5) Phasing of wildlife data collection with other ecological land data collection

The terms of reference should help to clarify the logistics of how the wildlife surveyor will be integrated with the rest of the ELS team, so that a proper phasing of data collection and exchange of data will occur. Prescott (1980) discussed the relative merits of wildlife sampling before, during, and after the Ecological Land Classification. He concluded that collection of wildlife data was most effective subsequent to the collection and mapping of other ecological land data. The main problem associated with collecting wildlife data before the ELC was that the habitat classification scheme of the wildlife biologist did not often lend itself to integration with that of the ecological analyst. Collection of data concurrently with the other ecological land data suffered from the following limitations:

1) There was no readily available and reliable data base on which to design the wildlife survey program (for stratifying surveys);
2) When preliminary polygons were used to establish the initial wildlife sampling locations, some sites were changed following ground truthing and boundary change (this seriously affected the adequacy of the wildlife sample);
3) Modification of the ecological analyst's ground truthing data collection techniques, to include wildlife values, was only partially effective due to small sample sizes and inappropriate techniques (e.g., plots of insufficient size and number); and
4) Ecological analysts tended to avoid ecotones, thus limiting sampling of this important habitat element for wildlife.

The client should also be aware that the results of the wildlife survey may influence the final boundaries of map units. There are a number of possibilities for the integration of wildlife data collection. Since none of these is "carved in stone", it is in the client's best interest that their pros and cons be discussed during the survey proposal step.

THE WILDLIFE COMPONENT OF THE ECOLOGICAL LAND CLASSIFICATION (ELC)

Most ELCs may be partitioned into three fundamental phases:

1) Pre-field preparation;
2) Field-data collection; and
3) Post-field data organization.

The relative amounts of time and effort dedicated to each phase will vary considerably between ELCs. For example, the relative proportion of time required for field data collection will be reduced if previous survey or intensive wildlife habitat use studies have been conducted in the mapping area. Similarly, detailed discussion and planning of the integration of the wildlife field component with other aspects of ecological data collection during the survey proposal step will reduce the time required for this task during the pre-field preparation stage of the ELC. Other influencing factors are funding level, remoteness of survey area, mapping scale, and the objectives, scope, and detail of the ELC.

1) Pre-field Preparation

The main objective of this phase is to provide an organized framework for the collection and subsequent evaluation of wildlife data. This framework should be constructed in such a manner that it optimally fulfills the wildlife-related survey objectives. The following is an overview of some of the basic tasks that should be addressed during pre-field preparation of an ELC. These tasks are arranged roughly in the order that they should occur during a typical ELC:

1) Construct detailed phasing schedule and timetable

As previously mentioned, some of this may have already been accomplished during the survey proposal step. At this point, it should have already been decided whether the wildlife field data collection will occur before, during, or after the other ecological land data collection. However, it is still necessary to finalize the details of wildlife integration and to construct a timetable of the tasks to be completed. Some of the types of questions that may have to be answered at this point are:

- What existing land data and map/air photo materials will be available to the wildlife biologist at the time of field sampling?
- What is the exact time frame available for wildlife data collection?
- Will the wildlife biologist sample in the immediate vicinity of vegetation plots and soil pits or will he/she travel to the same site as the remainder of the crew but sample in areas removed from these sites?

Answers to these questions should be dealt with through discussions between or among team members.

A detailed timetable should be designed that illustrates the various tasks and their timing relative to one another. Timetabling, as well as other details of the pre-field preparation, is often constructed during proposal preparation, in a competitive bidding situation.

2) Finalize details of wildlife sampling methodology

Some reference to general methods of sampling will usually have been made during the survey proposal step (e.g., winter tracking vs. pellet counts vs. aerial surveys). It is now time to finalize the details of the chosen sampling procedure. Are pellet count plots preferable to transects? Should rapid aerial waterfowl reconnaissance surveys be chosen over detailed ground counts of representative map units? Decisions made must satisfy survey objectives while meeting budgetary limitations and be tailored for integration with other ecological aspects of the ELC. Chapter 4 of the draft report reviews some of the standard wildlife survey techniques and discusses their applicability to different types and scales of ELC.

3) Conduct literature review

A detailed literature review should be conducted concerning the distribution, abundance, and ecology of the wildlife species of interest in the study area. Normally, featured species will have been chosen prior to this point. Such sources as existing surveys, site-specific environmental impact studies (government or industry), and species-specific research studies (government or university) should be accessed. The retrieval of wildlife habitat use data should be stressed during this review.

Other possible sources of wildlife data include: Interviews with species experts (usually government biologists or university researchers); interviews with local naturalists; and interviews with local residents, outfitters, etc. Two additional considerations for the review may be: 1) compilation of an annotated bibliography; and 2) listing of limitations of the data base (i.e., to highlight possible research needs for the improvement of future resource inventories).

Undoubtedly the most important aspect of a literature review for the wildlife component of an ELC is the retrieval of data and information that will aid in the selection and ranking of habitat attributes. In this regard, it may be useful to organize the review in such a way that sources of literature are related to the data and information that they provide on various combinations of wildlife species/land attributes. Similarly, it may be of value to structure interview questions such that the relative importance of land attributes to wildlife can be assessed (e.g., a survey of environmentally sensitive riverine habitats near a large urban centre requires baseline information on the relative importance of vegetation cover types to songbirds). In this instance, it would be very useful to provide some of the local bird experts (e.g. from a natural history club) with a listing of the major vegetation communities, and ask them to rate each of these habitats as to their potential to sustain breeding bird populations.

4) Identify diagnostic habitat attributes important to wildlife

Before mapping the preliminary map unit polygons using remote sensing procedures, it is useful to identify the relative importance of habitat attributes that will be used to identify boundary lines. These attributes, which can be identified and delineated using remote sensing, have been termed diagnostic features (Leskiw et al. 1984) and include landform, aquatic form, relief, elevation, moisture regime, and, at larger mapping scales, vegetation cover type. By rating the various types and classes of these features as to their importance to wildlife, it allows the ecological analyst to make mapping decisions that will facilitate wildlife field data collection and ultimately lead to a more meaningful evaluation product.

Two examples of mapping decisions that are aided by determining relative importance values of habitat attributes to wildlife are:

a) When portions of an area have similar habitat attributes (e.g. similar in all aspects except that one is morainal vaneer over bedrock and the other is morainal veneer over residum), the mapper must decide whether to searate this area into two units or lump the two into one unit. He/she refers to the importances values for landform types and finds that the two differ greatly in their importance values to wildlife, and in fact, morainal veneer over bedrock is a highly rated landform attribute. This information enables the mapper to decide that it is worthwhile to separate the two areas.

b) In situations where the ELC map base is being constructed from one or more existing land surveys, the mapper is able to decide when to group or separate smaller or larger map units or when to add inclusions that may be mappable at a larger scale.

5) Conduct preliminary delineation of map unit polygons

Initial landscape stratification is achieved through interpretation of aerial photographs or Landsat images. It is beyond the scope of this report to enter into detailed discussion of remote sensing technology. Suffice it to say that visual interpretation of conventional black-and-white panchromatic photography is currently the most commonly used technique. The following sequence outlines mapping steps followed for a 1:250 000 scale ELC that incorporated wildlife values into the preliminary map unit delineations (adapted and simplified from Leskiw et al. 1984):

a) Highlight map unit boundaries based on landforms and relief at scale of source data using relative importance ratings to determine which units to separate.

b) use differences in vegetative cover to subdivide the above boundaries, again using relative importance ratings to separate or combine vegetation types.

c) Transfer boundaries to a 1:250 000 scale base and delete map units less that about two and one-half square kilometers if they represent different relative importance categories (relative importance ratings were lumped into 4 separate categories).

Again, this is but one example of mapping guidelines for initial map unit stratification, but hopefully it clarifies the general concept. It is instructive to note here that not all, in fact not many, ELC's incorporate wildlife values into the mapping process at such an early stage. To-date this has primarily occurred in the case of surveys that were designed specifically for the wildlife resource. (Leskiw et al. 1984; Demarchi et al. 1983).

6) Select field sampling sites of locations

The field survey and sampling strategy should be designed to verify or modify the preliminary ELC interpretations and to collect wildlife population and habitat use data which could not be obtained via remote sensing. Quantitative data are most commonly collected for soils, vegetation, and wildlife, with some qualitative, descriptive notes being taken for landforms, aquatic forms, disturbances, etc. The bulk of the following discussion will involve wildlife sampling. As has been mentioned previously, wildlife may be sampled before, during, or after the ELC mapping. For the purposes of this discussion, and since sampling prior to mapping is not recommended, it will be assumed that the wildlife biologist has, at minimum, the preliminary map unit polygons with which to stratify sampling.

Verification and/or modification of preliminary map unit designations is accomplished primarily through the collection of soils and vegetation data. Soils and vegetation scientists typically work as a team at the same site. In terms of vegetation, plots are generally established in homogeneous areas representative of the predominant vegetation of selected polygons. Since soil is not directly detectable using remote sensing, and is usually related to landform and vegetation type, it is usually sampled at the site originally chosen for physiographic or vegetative characteristics. Wildlife values may be sampled at the same site, or even in the same plot as the vegetation sample, but there are definite drawbacks to restricting wildlife data collection to this situation, as discussed earlier.

To obtain an objectice and reliable wildlife sample within the framework of an ELC, it is advisable to design a sampling strategy that is independent of the constraints of the soils/vegetation component. If time and budget factors allow this, then the following considerations whould be made when selecting sampling sites or locations:

a) Attempt to achieve a statistically valid sample for each of the attributes sampled (e.g. vegetation type, aspect, landform class, etc.). Short of statistical validity, which is often very difficult to achieve in survey situations, attempt to sample attributes in as even a manner as possible.

b) Attempt to sample as full a range of attributes as possible (i.e. do not under-represent or forget such disturbance features as burns, clearcuts, avalanche tracks, etc.).

c) Avoid placing plots or transects near major active disturbances such as heavily used roads and active oil/gas wells when attempting to assess the inherent capability of a given attribute. If land disturbances are included as a supplemental attribute at the map unit level, then this is not as much of a consideration.

d) Attempt to sample for edge effect and habitat juxtaposition (e.g. use sampling methodologies that cross habitat boundaries or take you along an ecotone between habitats).

e) Avoid oversampling of areas that are known to be highly unsuitable to the featured wildlife species (e.g. large tracts of pastureland or homogeneous pine forest in upper subalpine areas). Instead, concentrate on the sampling of rare, but highly productive habitats or even sub-components of more common productive habitats (e.g. aspen forests with dense shrub understory versus aspen habitats with grass as the primary understory component). This is especially important when low budgets or inhibitively large study areas limit sampling intensity.

f) When sampling for vegetation type, be careful to avoid placing the sample in or near an unmappable inclusion of a different vegetation type. If, however, your sampling unit is the map unit as a whole, and the data will be analyzed at the map unit level, then the sample may incorporate the inclusion. Maximum size criteria of inclusions should be set prior to field sampling.

g) Avoid locating sampling sites on or near the edge of map unit boundaries or abrupt ecotones between vegetation types.

h) Distribute sampling effort relatively evenly throughout the geographic extent of the study area.

i) Attempt to sample map units that include a range of attributes that best represent other map units. Unfortunately, it is a rare ELC indeed that allows a statistically valid sampling of the full range of available map units. Therefore, selection of representative map units for extrapolative purposes is very important.

j) Consider sampling pre-determined combinations of attributes, e.g. aspen forest on steep south-facing slopes of glacio-fluvial landforms. Try to obtain sufficiently large sample sizes for combinations deemed to be important.

7) Prepare data sheets

Data sheets are necessary to efficiently organize collected survey data. There is currently no such item as standard sampling form for a given survey technique, mainly because of the large amount of variability in the detail, scope, objectives, etc. between projects.

8) Orient the field crew

For larger surveys, which require the hiring of three or more biologists, it is vital that the crew leader(s) conduct an orientation session to familiarize crew members with the field techniques and to instruct on the standarization of data collection. At this point, field staff can brush-up on plant identifications, and it may also be wise to supply field staff with a list of the dominant tree and shrub species in the study area that they can study prior to data collection. Field staff should also familiarize themselves with the common landform and aquatic classes during this orientation period. The orientation session should last at least one full day.

2) Field Data Collection

Current wildlife habitat use data are essential for any ELC that intends to seriously incorporate wildlife values. The relative importance of a map unit to a wildlife species can sometimes be inferred through expert analysis and/or computer modeling of the particular combination of habitat attributes occurring within it. After all, why absorb the costs associated with field studies when the existing habitat attributes can indirectly tell us how important the map unit is to wildlife? There are a number of reasons why this is not advisable, at least currently, and in fact can lead to highly misleading interpretations of wildlife habitat importance.

1) Wildlife use of habitat is a very complex and dynamic process, the details of which are currently poorly understood for a large number of species.
2) Wildlife use of habitats is often "area-specific" and, as such, generalizations or extrapolations from existing studies to other areas may not be valid.
3) "Modeling" of wildlife habitat suitability or capability is a fairly new and evolving field that presently relies on "on-site" field data for refinement and/or validation - it should not be considered as an end in itself at this stage in its evolution.

4) Assessment of the relative importance of map units solely through manual assessment by regional experts is far too subjective to match the levels of detail inherent to most ELCs (or the current need for refined wildlife management).
5) Results of site-specific, current wildlife habitat use field studies reflect effects of current land use disturbance -- this important factor is not easily represented through modeling or expert analysis.

Hence, wildlife managers and land planners must recognize that site-specific wildlife field data collection is an integral component of a complete and objective ELC.

Some of the principal functions of wildlife field data collection within an ELC context are:

1) To attain an objective measure of relative levels of use of map units, landforms, vegetation, combinations of land attributes, etc.
2) To establish benchmark population density values that may be used to estimate the wildlife carrying capacity of map units.
3) To verify or provide an objective framework for population density estimates generated by wildlife/habitat modeling procedures.
4) To locate areas of "critical wildlife habitat" and/or particularly significant concentrations of wildlife.
5) To establish baseline populaticn data for future long-term monitoring.
6) To familiarize the survey biologist with the study area. There is no substitute for "hands-on" contact with wildlife use of map units, in terms of subsequent assessments and report production.

Wildlife survey methods for ELC are many and varied. By necessity, the techniques used generally do not involve direct or detailed observation of wildlife or their behavior. ELCs usually encompass extensive areas and, unfortunately, rarely seem to accommodate long-term data collection. Therefore, methods have evolved which attempt to quantify wildlife use rapidly, and in many cases indirectly. A typical example is the pellet group count method, which has been used extensively as an ungulate survey procedure (Prescott 1980; Holroyd and Van Tighem 1983; Demarchi et al. 1983). Field data collected using "quick-and-dirty" inventory techniques should not be used as the final and ultimate determinant of the relative importance of map units to wildlife. There are simply too many variables involved in the complex relationship between wildlife and habitat, to be detected accurately using short-term survey techniques. However, by combining various other sources of habitat use data (i.e. consultation with species experts; existing wildlife/habitat attributes) with rigorously collected site-specific field data (as an objective guideline), it becomes possible to assign reasonably accurate importance ratings to map units. For some species groups, it is possible to use more than one field survey method. For example, it is possible to measure ungulate use of map units by pellet group counts, winter tracking, browse/forage use surveys, and aerial surveys. By using more than one technique, the biologist can internally verify the accuracy of the findings.

The wildlife survey techniques employed for a given ELC depend on many factors, including:

1. The featured species or species groups to be surveyed;
2. The types and detail of data required (i.e. relative habitat use vs. population estimates vs. diversity indices, etc.);
3. The scale of mapping;
4. Field logistics;
5. Funding levels;
6. Quantities of baseline wildlife data already available; and
7. The timing of field data collection relative to ecological land analysis.

A number of wildlife survey techniques may be applied to ELC. The manual will review the more commonly used of these procedures and will include discussion as to how some of the above-mentioned factors may influence choice of methods. An example follows:

Mammals

1) Pellet group counts:

a) Species applicability
   - ungulates
   - hares and rabbits.

b) Overview of technique
   - for ungulates, groups of pellets are censused in a series of plots or along transect lines. Plots or transects are placed in homogeneous vegetation types within map units.

c) Scale of mapping applicability - 1:500 000 to 1:250 000.

d) Information gained
   - relative use of map units, vegetation types, valley systems, and landforms.

e) Limitations of technique
   - mere presence of pellets does not indicate type of use (i.e. feeding vs. bedding vs. travelling)
   - Ungulates may not defecate at the same rates in various habitat types.

f) Advantages of technique
   - generates large sample sizes (n)
   - relatively inexpensive
   - collects data that have been accumulated over an extended time period (e.g. November-May).

2) Winter Tracking, etc.

*Note: For the final manual, this section will include discussion of the major inventory techniques for all brood species groups (Mammals, Birds, Fish, and Herptiles). Its completion hinges partially on further discussion with and input from workshop participants.

3) Post-field Data Organization/Revision

This stage of the ELC involves summarization of data and revision of the preliminary map unit boundaries and associated ecological data. Revision of map unit polygons is most often related to the results of the soil and vegetation ground truthing. However, for ELCs that consider wildlife as a significant component, map unit boundaries may be altered based on the wildlife field data collected. For example, a 1:10 000 scale ELC initially fails to distinguish trembling aspen-ryegrass stands on south-facing ravine slopes from trembling aspen-red osier dogwood stands on north-facing slopes. Subsequent field studies show that north-facing slopes support significantly higher breeding bird densities and winter white-tailed deer use. If songbirds and deer were considered as important species in the area, it would then be advisable to map and rate these two aspects (i.e. north vs. south) separately.

Data should be summarized and analyzed at various levels of detail for those habitat attributes important to wildlife species or species groups. For example, pellet count data may be grouped by watershed, map unit, or recurring combination of map units, vegetation community, landform, soil category, aspect, slope class, elevational range, etc. Grouping and initial analysis of data are most efficiently accomplished through the use of a computer. For further evaluations, the size of the samples should be considered. Raw data should be stored in such a manner that rapid retrieval is facilitated. Sampling locations should be geographically referenced for site-specific impact assessment purposes.

For any ELC that includes a significant wildlife field component, all wildlife field personnel should meet for discussion immediately after completion of the field program. This meeting, which should also be attended by other members of the integrated ELC team, would address:

1) Limitations of wildlife field techniques (logistics, sampling design, etc.).

2) Specific wildlife/habitat relationships that may not be borne out by the data evaluation but should be discussed in text-based species accounts (e.g. consistent winter "yarding" of deer in north- to east-facing pine forests with subalpine fir regeneration in the understory, or observations of heavy predation of mallard nests by coyotes along narrow hedgerows).

3) Recommendations for map unit boundary changes.

4) Mapping errors -- Some ELCs use existing soils and vegetation surveys to map polygons, without implementation of field sampling. In these instances, the wildlife biologist may serve as a ground truthing source, and may be able to point out vegetation cover mapping errors or omissions.

5) Suitability of certain habitat attributes for subsequent evaluation of map units -- Immediately after intensive field sampling, a biologist is in an ideal position to recommend which land attributes are of primary importance as predictors of wildlife resource values (e.g. he/she may notice that breeding birds are responding in significantly different ways to various successional stages of forest regrowth in logged areas). Communication of this occurrence to ELC mappers may lead to more detailed mapping and evaluation of these logged areas.

Hence, the post-field step of the ELC sets the organizational framework for more detailed evaluation of the wildlife field data collected.

THE WILDLIFE COMPONENT OF THE ECOLOGICAL LAND EVALUATION

The evaluation step provides interpretations of the ELC data base to achieve resource ratings or rankings which will facilitate decision-making by the wildlife resource manager or planner. Evaluations may vary widely in terms of complexity, ranging from subjective manual assessments of overall habitat suitability to detailed computer-modelling procedures that embody seasonal use values for different life requisites. Regardless of the sophistication of the process, the common objective of all evaluations with regard to wildlife resources is **to assess and rank the relative abilities of different map units to support wildlife populations.**

Some of the more significant and measurable map unit attributes may also be evaluated as separate entities. These might be vegetation community, landform type, aquatic class, etc. The extent to which this evaluation takes place will depend on the particular scope, detail, and objectives of the ELS.

Evaluations should be tailored to meet the user's/client's needs as originally expressed in the objectives of the survey proposal. These needs may be met by implementing the following types of resource evaluations, which are discussed in greater detail in the following paper by Kansas.

1) Population Status Assessments
   a) Current Population Status
   b) Critical or Key Area Designations;

2) Habitat Status Assessments
   a) Current Suitability
   b) Inherent Capability
   c) Potential Capability; and

3) Multiple Species Occurrence Assessments

It may be possible to evaluate wildlife resources in more than one of the ways referred to above. ELCs which use a wide range of assessments will, in turn, be adaptable to a wide range of resource management and planning scenarios.

The above assessments may be refined or qualified based on such criteria as:

1) habitat function - i.e. the life requisite(s) (feeding, breeding, cover);

2) Season of use;

3) Habitat trends (e.g. successional stages; actual and potential land disturbances); and

4) Population trends.

The capability and/or suitability of map units and land attributes may be assessed for: all wildlife species in the study area; key or featured species; management indicator species; or groups of species with similar habitat preferences (life forms or associations).

Some of the basic guidelines that should be adhered to when evaluating wildlife resource values within an ELC context are:

1) The evaluation must be as objective and repeatable as possible.
2) The evaluation should be no more sophisticated or complicated than needed to provide the desired answers or results to the user(s).
3) The types of evaluations used must produce ratings that match the perceived needs of the user/client.
4) When subjective ratings of habitat variables are a major component of the evaluation (e.g. in a modeling situation), the analyst must communicate the limitation of the techniques to the user/client.

A detailed overview of resource evaluation rationale and methods will be presented in Chapter 5 of the manual.

SURVEY PRODUCTS — MEETING THE LAND USE PLANNER'S NEEDS

General Guidelines

The ultimate measure of success of any ELS is the degree to which it can be effectively understood and implemented by the user/client. Even the most thoroughly collected and evaluated wildlife data base may be limited in its effectiveness if the survey products are not clearly presented and tailored to the needs of the user. The following presents some general principles and guidelines which can be used to better identify what should constitute the various components of a final ELS end product:

1) Survey products should be directly tied to, or be a reflection of, the original objectives of the ELS.
2) Survey end prodcuts should be pre-determined by the user/client in cooperation with the ELS team (ideally, at the survey proposal stage, to allow wildlife biologists to tailor field data collection and evaluation to subsequent presentation products). Cooperation with the ELS team (ideally at the survey proposal step, to allow wildlife biologists to tailor field data collection and evaluation to subsequent presentation products).
3) Wildlife products or interpretations should be developed primarily from the ELS data base.
4) When possible, wildlife interpretations should be displayed in a single purpose or thematic format.
5) Survey products should provide a balanced textual, tabular, and cartographic presentation.
6) For survey products to meet a multiplicity needs, the information should be evaluated presented at different levels of generality even within a common map scale.
7) Survey end products should be adapted to the management and planning activities under consideration, as well as to the kinds of questions that are being asked and need to answered.
8) A conscious effort should be made to achieve an uncluttered, "user-friendly" end product, that does not intimidate or confuse the user with excessive detail and scientifc jargon.
9) Raw data from the field data collection step should be appended to the final report or should be stored in a manner that allows quick and easy access.

Report Components

For detailed discussion purposes, the final ELC wildlife-related products will be divided into the following categories:

- Cartographic (maps and overlays)
- Tabular (wildlife legend)
- Textual
- Computer
- Photographic.

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USING ECOLOGICAL LAND SURVEYS TO AID THE EVALUATION OF WILDLIFE RESOURCES

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INTRODUCTION

Ecological Land Survey (ELS) provides a relatively stable geographic framework for the recognition, classification and evaluation of wildlife populations. This land survey system is based on the delineation and description of ecologically significant units of land. Each unit can be characterized by its inherent and distinctive combination of climate, geology, physiography, surface materials, soils, hydrology and vegetation (Wiken 1980). The basic assumption underlying the usefulness of ELS for evaluating wildlife resources is that wildlife species select for specific attributes of their total environment in a reasonably predictable and meaningful manner at different times and stages of their seasonal and reproductive cycles. This assumption is supported both by ecological theory (Hoekstra, Flather and Ironside 1984, Flather and Hoekstra 1985), and numerous scientific field studies of wildlife habitat utilization (e.g., Rongstad and Tester 1969; Peek et al. 1976, Tilton and Willard 1981, Cook and Irwin 1985). Thus, it follows that specific environmental parameters, as classified and mapped into distinctive units by the ELC process, may have either enhancing or limiting influences on wildlife populations.

It is both economically and logistically unreasonable to assume that wildlife managers can respond to land use conflicts with detailed and specific population data for the majority of species occurring in a given area. Direct observations of wildlife populations is frequently a time consuming and costly process. A logical supplement or alternative to direct population data is to observe and measure the land-based requirements for food, cover and space of the species or species group in question. These requirements are met at different times of the year by varying combinations of the above-mentioned environmental parameters that characterize units of the ELC system.

EVALUATION PROCEDURES

Three general steps comprise the utilization of ELS for evaluating wildlife resources, as follows:

1. selecting priority wildlife species.
2. selecting the "best" land attributes.
3. evaluating land unit importance.

Selecting Priority Wildlife Species

Few Ecological Land Surveys are able to accommodate data collection for all or even most wildlife species in the management area. Hence, it is important that the best possible combination of species be chosen. The ultimate choice of priority species will depend on the specific goal(s) of the survey. Most surveys should, however, share the common goals of maintaining 1) optimum species diversity and, 2) population viability of selected species. In the United States, these selected species are termed "management indicator species", which act as sensors at critical spots in the planning unit (Harcombe 1984). They are selected primarily because changes in their populations are thought to best indicate overall effects of management activities.

Salwasser and Unkel (1981) list three essential criteria for the selection of management indicator species:

1. all listed rare, threatened and endangered species.

2. all sensitive species whose populations or habitat are measurable and will be affected by anticipated vegetative manipulation.

3. significant harvest species and highly valued non-consumptive species identified in planning issues.

Additional criteria that should be used to choose management indicator species are:

4. species with specific habitat needs that will be affected by planned management programs.

5. species whose populations indicate the welfare of other species that are important in forest management.

6. species that are dependent on early successional vegetation.

7. species that are dependent on late successional vegetation.

The choice of indicator species may be facilitated by the grouping of several species into "life forms" or "guilds". The life form concept groups wildlife species based on similarities of reproductive and feeding use of habitats (Thomas et al. 1979), while Root (1967:335) defined a guild as "... a group of species that exploit the same class of environmental resources in a similar way. This term groups together species, without regard to taxonomic position, that overlap significantly in their niche requirements." In this way, planners may eliminate excessive data collection by choosing a single, easily monitored species whose population changes should, in theory, indicate the welfare of other species within the same guild or life form. Figure 1 provides an example of life form designations from Thomas et al. 1979 (in Harcombe 1984).

Wildlife managers should also take into account home range size of the candidate priority species relative to the proposed scale of mapping of the ELC. Importance ratings of individual land units are not always meaningful for large, wide ranging species at large mapping scales. For example, at a mapping scale of 1:250,000, the home range of a grizzly bear in the Rocky Mountains of Alberta may encompass in the order of 15-20 land units. Similarly, it becomes difficult to rate the relative importance of land units to smaller species such as breeding birds and small mammals, at mapping scales of 1:100,000 and broader. Such wildlife species tend to perceive and utilize their environment at fine levels of detail, and respond to subtle variations in vegetation type that may not be delineated at smaller scales of mapping.

Finally, consideration should be given to the ease and economics of monitoring of would-be priority species. Species chosen should lend themselves well to cost-effective and repeatable field data collection within a mapped habitat framework.

Selecting the "Best" Land Attributes

A. General

Land attributes that are of importance to wildlife populations can be broadly divided into soils, terrain, vegetation, hydrology and climate. These components can then be further subdivided into numerous sub-components or variables, as illustrated in Table 1. Since it would in most cases be economically impossible to comprehensively map and analyze all of these parameters, it is essential that the most applicable and cost-effective land attributes be identified for inclusion within the ecological land survey or wildlife habitat inventory. The diversity and detail of land attributes used to assess wildlife resource values will depend primarily on the scale of mapping (map unit size), scope, detail and objectives of the Ecological Land Classification project conducted.

1. Scale of Mapping

As a general rule the number and detail of land attributes selected will increase as mapping scale increases. As an example, aspect is known to be an important landform feature affecting the distribution and relative abundance of ungulates. At scales of 1:250,000 and smaller it is difficult to assign aspect classes to land units because of their relatively large size and high degree of landform heterogeneity. However, at scales of 1:50,000 and larger, map units are small and physiographically simple enough, that aspect becomes a measurable and characteristic component.

2. Scope or Detail

Selection of land attributes will be greatly influenced by the species or

Life Form	Reproduces	Feeds	No. of Species[1]	Examples
1	in water	in water	1	bullfrog
2	in water	on the ground, in bushes, and/or in trees	9	long-toed salamander, western toad, Pacific treefrog
3	on the ground around water	on the ground, and in bushes, trees, and water	45	common garter snake, killdeer, western jumping mouse
4	in cliffs, caves, rimrock, and/or talus	on the ground or in the air	32	side-blotched lizard, common raven, pika
5	on the ground without specific water, cliff, rimrock, or talus association	on the ground	48	western fence lizard, dark-eyed junco, elk
6	on the ground	in bushes, trees, or the air	7	common nighthawk, Lincoln's sparrow, porcupine
7	in bushes	on the ground, in water or the air	30	American robin, Swainson's thrush, chipping sparrow
8	in bushes	in trees, bushes, or the air	6	dusky flycatcher, yellow-breasted chat, American goldfinch
9	primarily in deciduous trees	in trees, bushes, or the air	4	cedar waxwing, northern oriole, house finch
10	primarily in conifers	in trees, bushes, or the air	14	golden-crowned kinglet, yellow-rumped warbler, red squirrel
11	in conifers or deciduous trees	in trees, in bushes, on the ground, or in the air	24	goshawk, evening grosbeak, hoary bat
12	on very thick branches	on the ground or in water	7	great blue heron, red-tailed hawk, great horned owl
13	in own hole excavated in tree	in trees, in bushes, on the ground, or in the air	13	common flicker, pileated woodpecker, red-breasted nuthatch
14	in a hole made by another species or in a natural hole	on the ground, in water, or the air	37	wood duck, American kestrel, northern flying squirrel
15	in a burrow underground	on the ground or under it	40	rubber boa, burrowing owl, Columbian ground squirrel
16	in a burrow underground	in the air or in the water	10	bank swallow, muskrat, river otter
		TOTAL:	327	

Figure 1. An example of life form descriptions (from Thomas et al. 1979 in Harcombe 1984).

Table 1. A listing of some habitat variables that are associated with each of the 5 broad land attributes that influence wildlife distribution, diversity and abundance.

CLIMATE	HYDROLOGY	TERRAIN	SOILS	VEGETATION
Snow depth	Lake depth	Aspect	Type	Successional stage
Rainfall levels	Stream width	Slope	Texture	Canopy cover
Wind	Turbidity	Parent material	Drainage class	Interspersion
Permafrost	pH	Elevation	Productivity	Composition
Temperature	Pool/Rifle ratio	Surface expression	pH	Physiognomy
Albedo	Flow character	Relief	Porosity	Productivity
Winter severity	Salinity		Soil Zone	Strata diversity
	Water level stability			Compositional diversity
	Flow volume			

species groupings of concern. If the inventory were solely concerned with ungulate species, the land attributes chosen would differ widely from those that would be chosen if non-consumptive wildlife values (e.g., breeding birds) were the primary consideration. For example, snow depths would be an important variable to measure for the ungulate inventory, whereas it is unlikely that this variable would receive consideration if breeding birds were the sole concern. There does, however, exist considerable potential for overlap of attributes of importance. For example, vegetation strata diversity is highly important to both breeding birds and ungulates. For inventories which include a wide range or particular combination of wildlife species it becomes very practical to isolate and utilize those land attributes that are important to the greatest number and/or groups of species.

3. Objective

The overall or primary objective of the inventory will often determine the selection of land attributes for wildlife resource evaluation. For example, if the primary goal of the inventory was to predict and assess vegetation and wildlife responses to land-based management activities, a detailed assessment of the successional stage of each vegetation cover type would be necessary. Conversely, if the primary motivation for a wildlife inventory was for non-consumptive use by recreationists (e.g., National Park), then successional stage may receive limited consideration.

Another example of the influence that specific objectives have on selection of the most suitable land attributes, is the basic choice of assessing inherent land capability versus current land suitability. These two concepts are discussed in detail in the preceding paper by Stelfox on wildlife resource evaluation. If the wildlife resource manager is interested solely in inherent land capability, then the vegetation component would not require intensive inventory, whereas an assessment of current habitat suitability would require detailed vegetation description, including seral stage designations.

B. Methods

An essential first step towards selecting the most suitable land attributes is to conduct a review of the known habitat

Letter code	Life form	Species	Versatility rating[1]	Activity: Seasonal Occurrence[2] January	February	March	April	May	June	July	August	September	October	November	December	Reproduction capacity potential per year	Home range (h.r.) or territory size (terr.)	Plant Communities[3] Dry meadow	Moist meadow	Other grasses	Sagebrush-bitterbrush	Other shrubs	Western Juniper	Quaking Aspen
MAMMALS																								
LYCA	5	lynx	M	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	1-4; avg. 2; 1 litter						● ■		
LYRU	4	bobcat	H	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	1-6 avg. 3-4; 1 litter	518 ha (1,280 acres)	■	■	■	● ■	● ■	■	■
EQCA	5	feral horse	M	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	1-2; avg. 1 foal		● ■						
CEEL	5	elk	M	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	1-2 calves		■	■	■		● ■	■	● ■
ODHE	5	mule deer	M	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	1-2 fawns		■	■	■	■	● ■	■	● ■
ODVI	5	white-tailed deer	L	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	1-3; avg. 2 fawns			■	■		● ■		● ■
ANAME	5	pronghorn	M	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	1-3; avg. 2 kids		● ■	● ■	● ■	● ■	■	● ■	
ORAM	4	mountain goat[10]	L	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	1-2 kids								
OVCA	4	big horned sheep[10]	L	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	1-2; avg. 1 lamb								

[1] Versatility Rating
L = low
M = medium
H = high

[2] Activity
Reproductive activity
▨ Feeding activity

[3] Plant Community Function
■ Primary Feeding (>40%)
□ Secondary Feeding (<40%)
● Primary Reproduction (>40%)
○ Secondary Reproduction (<40%)

Figure 2. Matrix of species/habitat relationships from the Blue Mountains of Oregon (adapted from Thomas 1979:244-245).

requirements of the wildlife species or species groupings (life forms or guilds) of concern. This review may be completed in the form of species narratives (Harcombe 1984). This format summarizes pertinent details about the natural history of each species within a standard taxonomy classification framework. Information categories that may be considered include:

1. Taxonomy
2. Status and abundance
3. Optimal habitat or distribution/habitat
4. Special habitat requirements
5. Breeding
6. Territory/home range
7. Food habits
8. Distribution or range maps
9. References

The detail with which these narratives are conducted will of course be determined by the scope (and detail) of the ELC project planned.

Once the species narratives have been compiled they can be used to prepare written or tabular summaries of key habitat requirements and other special ecological considerations, for the chosen wildlife species. These summaries should include documentation on the influences of a range of environmental attributes (e.g., climate, soil, vegetation, landform, etc.) that have positive or negative effects on the primary life requisites of the wildlife species of concern. In tabular format these summaries are termed species/habitat matrices. Figure 2 shows one such matrix from Oregon adapted from Thomas (1979). This matrix divides habitat attributes into plant community groups, special habitat components and unique habitats (cliffs, talus, caves). Theoretically, this system could also accommodate different and/or more detailed land attributes such as canopy closure, aspect, etc.

Subsequent to the preparation of key habitat summaries, it is necessary to organize the information in such a way that a logical and reasonably objective selection of the most suitable land attributes can be made. This can be accomplished through the construction of two-way matrix tables that rate the relative importance of different land attributes to priority wildlife species or species groups. Table 2 provides an example of this technique as used for mammal inventories of the Atlantic provinces (Prescott 1980). This system utilizes a five-part rating of the strength of overall influence of the particular attribute on the species, and then averages these values for all species to produce an overall index for each land attribute. This may be adapted and refined in a number of ways to suit the specific scope and objective of the ELS project. For example, all ungulates could be lumped together to produce an overall rating or consideration may be given to the relative influence of attributes on feeding vs. reproduction vs. shelter requirements. A weighted rating system may then be used to accommodate the relative importance of these primary life requisites. Again, the detail, scope and objectives of the ELS will ultimately govern the exact system used.

In summary, the final selection of environmental parameters to be included in the inventory project will be based on the following:

1. Their overall usefulness in assessing wildlife habitat for the species or species groups identified, using a weighted rating system.

2. The relative economic cost/benefit of incorporating a given environmental parameter into the study. In some cases, practical emphasis may have to be placed on those parameters which can be remotely sensed or for which reasonable quantities of relevant information already exist.

C. Vegetation Versus Other Parameters

It is generally assumed, and usually with good reason, that vegetation characteristics are the most relevant to an inventory and assessment of terrestrial wildlife habitat. This statement is supported by Harcombe (1984) who, upon reviewing many existing conceptual models of wildlife in managed habitats, stated that the most important attributes of habitat needed to describe the basic resources essential to wildlife were successional stage, structure and canopy closure of vegetation. Prescott (1980) also noted that besides snow accumulation, all of the important components of their habitat (influencing mammals of the Maritime region) were vegetation characteristics (e.g., canopy and shrub layer composition). Vegetation provides most food requirements (with the exception of water and some trace minerals) for the

Table 2. Relative values of various habitat descriptive factors that influence mammals in their choice of habitats.*

	SPECIES GROUPS																										
INFLUENTIAL HABITAT FACTORS	Shrews	Moles	Bats	Snowshoe Hare	Arctic Hare	Squirrels	Beaver	Mice and Voles	Muskrat	Porcupine	Coyote	Fox	Black Bear	Raccoon	Weasel	Marten	Otter	Mink	Lynx	Bobcat	Caribou	White-tailed Deer	Moose	AVERAGE	Moderate	Strong	Very strong
Abiotic																											
Geology		1	1				1		2															0.2	-	-	-
Surficial Materials		2				1	2	1	3		2	2	1											0.6	1	-	-
Soil Type	1	5				1	2	2	2		1	2										1		0.7	-	-	1
Topography	2	4	1	1	4		4	1	4					2		1	2	1	1		3	3	1	1.5	2	4	-
Aspect	1			1	1	1		1		1											2	4	3	0.7	1	1	-
Slope	2	2		2	3		4	2	4								2	1			2	4	3	1.3	2	3	-
Drainage	3	4				1	3	2	4				1	2			1	1			2	2	2	1.2	2	2	-
Climate -																											
season length	1	2	1	2	2	2	4	3	3	1	1	1	2	3	1	1	2	1	1	1	2	3	2	1.8	4	1	-
wind			1	3	4					1	1	1				1			1	1	2	3	2	0.9	2	1	-
snow	3	2		3	3	2	2	4	3	2	2	2	1	2		3	1	2	2	3	4	4	2	2.3	4	4	-
rain	1	1			2		3	1	2											1	1	1		0.6	1	-	-
temperature	2	1	3	2	1	4	4	2	4	1			2	3			3	2	2	2	1	3	1	1.9	4	3	-
Biotic																											
Vegetation -																											
Canopy-Composition	3	1	2	3	3	4	4	3		4	1	2	1	2	2	3	1	1	2	2	1	4	3	2.7	6	4	-
Density	2		3	3	4	2	3	4		1	1	2	3	3	2	4		1	2	1	4	3	2	2.2	6	4	-
Height	1			2	2	3	2	3		3				3	1	4			2	1	2	3	2	1.5	5	1	-
Shrub-Compositions	2	1		4	4	2	3	3		1	1	1	3	1	2	2		1	3	3	3	4	4	2.1	5	5	-
Density	2			4	2	2	2	2			1	1	2	1	2	2		1	3	3	2	3	2	1.6	4	1	-
Ground Cover-																											
Composition	4	3		3	3	2	3	4	4	2			2	2	2	2		1	2	2	5	3	1	2.2	5	3	1
Density	3	3		3	2	1	2	4	2	2			2	2	3	1		2	1	1	3	2	1	1.7	4	1	-
Insects & Invert.	4	5	5			1		3					2	3	3	2	1	2						1.3	3	1	2
Fish		1											2	2			5	4						0.6	-	1	1
Birds	2			2		2		2			2	2		2	1	3	1	2	2	2				1.1	1	-	-
Reptiles-Amphibians	1													2	1	1	2	1						0.3	-	-	-
Other Mammals	2	2		1	2	2	2	2	2	1	4	4	1	1	4	4		2	4	4	1	1		2.0	-	6	-
Human history -																											
exploitation				1	2		3		3	1	1	1	1			4	4	1	4	1	5	2	4	1.7	2	4	1
land use	2	3	2	3		1	2	2	3	1	3	3	2	2	2	4	1	1	3	2	2	3	2	2.1	7	1	-
Disturbance -	2	3	3	2	3	2	3	1	3	1	2	1	2	1	1	4	3	1	3	2	3	2	3	2.2	9	1	-
Type Size	1	2		1	2			1		1				1		4			3	1	4	2	1	1.0	1	2	-
Vegetation Diversity	2	1	1	3	1	1	3	2	1	2	2	2	3	1	2	4	1	1	2	2	2	3	2	1.9	4	1	-
Successional Stage	2			4	2	1	2	2	2				3	1		4			3	2	4	3	2	1.6	3	3	-
Proximity to Water	3	3	3				5		5					3			5	4				2	3	1.6	5	1	3

Strength of influence			
	0 - none	2 - weak	4 - strong
	1 - very weak	3 - moderate	5 - very strong

*From Prescott (1980).

primary consumers, and also provides many of the cover requirements for shelter and security of both primary and secondary consumers. On this basis it would seem logical to argue that a good vegetation classification and inventory is all that is required for the inventory and evaluation of wildlife habitat. There are however, several problems inherent in this line of reasoning, and these problems argue strongly in favour of a more holistic and integrated approach as is facilitated by Ecological Land Survey. The problems to be considered are as follows:

1. Current vegetation cover is a relatively unstable landscape feature that will require frequent reclassification and remapping as succession takes place.

2. In many cases, potential natural vegetation must be inferred from physical landscape features such as soils, parent materials and aspect.

3. Many vegetative characteristics, such as productivity and understory cover composition, do not lend themselves to remotely-sensed measurement.

4. A number of physical landscape parameters have significant direct and indirect implications to wildlife habitat, and many of these are amenable to remote-sensing interpretations; e.g., surface water characteristics as they contribute to habitat for aquatic furbearers and waterfowl; steepness, aspect and frequency of slopes as they influence abundance and distribution of ungulates.

5. Vegetation, as a single environmental parameter, does not provide a sufficient basis for understanding ecological landscape dynamics, or cause and effect relationships, that might facilitate the interpretation of both current and potential future wildlife habitat conditions, e.g., succession following burning of a north versus south facing pine slope.

6. A vegetation classification by itself would only allow an assessment of current habitat suitability, whereas the integration of soils and landform information facilitates an assessment of both current habitat suitability and inherent habitat capability.

7. In some cases a particular vegetation type may occur as structurally similar in areas with highly different physiography or climate. Inferences regarding similar wildlife values however, may be very misleading in these instances, as the combined influence of such attributes as aspect and snow depth may override vegetation similarities.

Evaluating Land Unit Importance

Once the habitat attribute data for individual land units is organized and presented in a usable format (e.g., an extended legend), it becomes necessary to assign values or ratings to the units in terms of their ability to support particular wildlife species or species groups. These values are usually presented in the form of relative classes of a multi-level rating scheme. Examples are the seven-tiered Capability Class System of ungulate and waterfowl CLI rating and the four-tiered (Best, Moderate, Poor, Inadequate) system used for the Prototype Wildlife Resource Status Assessments in Alberta (IEC/Beak Consultants 1985). For certain species it may be useful to assign population estimates (or carrying capacity ranges to each class or sub-class (e.g., Demarchi et al. 1982, IEC/Beak Consultants 1985).

There are three principal methods of evaluating the ability of land units to support wildlife populations. They are as follows:

1) Habitat Use Data Collection.

2) Subjective Manual Assessment.

3) Computer Modelled Assessment.

All three techniques are subject to a number of shortcominings, especially if used as single evaluation sources. When used in combination, however, they may serve as cross-checks and validators to one another and produce accurate land unit ratings.

A. Habitat Use Data Collection

Field data collection in the context of most ELS has historically involved rapid and indirect habitat use measurement in the form of ungulate pellet group counts, snow tracking transects, breeding bird song transects and small mammal trapping.

The primary advantage of these types of field surveys is that they provide the inventory biologist with objective, study area-specific habitat use measurements. Unfortunately, field assessments conducted over a short time frame (less than one full year) may provide misleading or inadequate habitat use information. Some ELS studies, such as the Biophysical (Ecological) Land Classification of Banff and Jasper National Parks (Holroyd and Van Tighem 1983), have partly avoided this problem by intensively and repeatedly sampling land units over an extended period (5+ years). Most ELS, however, are conducted over a much shorter period, usually less than a full year.

One of the major problems associated with short term field assessments is that they may not always reflect temporal non-habitat factors such as hunting mortality, predation, traditional land use patterns and indirect human harassment (e.g., intensive road traffic). This may be partially offset by stratifying field surveys to negate or control these parameters. This is not always possible, however, especially if little baseline information of this sort exists for the survey area. Another problem associated with short term field surveys is that they may reflect the particular weather conditions during the time of the survey. For example, if ungulate pellet group counts are conducted the spring after a particularly severe winter, abnormally high concentrations of pellet groups may be found in land units represented by high percentages of coniferous forest cover. If evaluated solely on the basis of field data, such land units may receive a higher rating than is actually justified.

In short, unless rigorous and long term (+3 years) field sampling is implemented, field surveys should not be used as the sole source of information for generating land unit ratings. Short term field assessments are most effective when used in conjunction with existing regional habitat use information and species expert opinion. Population and relative habitat use information gained from such assessments may be used to supplement, "fine-tune" and even validate (depending on survey design and intensity) subjective or modelled assessments. Reconnaissance field surveys become most important in situations where specific habitat use information is unavailable for the study area or for habitats similar to those existing in the study area. Another important advantage of field assessments is that they allow an evaluation of the impacts of current land disturbances. This is particularly valuable for an assessment of current habitat suitability.

Finally, there is no substitute for local field knowledge of a survey area, in terms of the quality and accuracy of final report preparation and recommendations.

B. Subjective Manual Assessment

This method of evaluation uses the collective judgement of "species experts" to produce an overall, subjective rating for the land unit and species in question. The expert biologist(s) use their local or regional knowledge of habitat-use of the species, along with biophysical information relative to the land unit, to rate the unit's suitability or capability. The success of this type of assessment hinges on three main factors as follows:

1. The type and level of detail of biophysical information presented for land units;
2. The amount of local or regional wildlife field experience of the expert biologists; and
3. The amount of existing habitat-use research and inventory information present for the survey area or representative ecoregion.

An attempt should be made to maximize all of these factors for any subjective assessment of land unit ratings. Careful selection and classification of appropriate land attributes will go a long way to improving the species experts' accuracy in assessing land unit importance. For example, if an expert moose biologist is supplied with information on understory strata diversity, he/she will be much more able to accurately assess land unit importance than if supplied solely with broad plant cover type descriptions.

Familiarity with the survey area, or at least regional field experience, are essential to a reliable subjective assessment of land unit importance. For this reason, a range of species experts (3 to 4) are more likely to provide an accurate evaluation than would a single biologist. Consideration should be given to conducting committee assessments that encourage information exchange between species experts.

Specific habitat-use research data, relative to the locality or region of the ELS, are very useful for aiding subjective assessments of land unit importance. Unfortunately, research studies specifically oriented toward habitat-use are relatively rare for most species. The usefulness of subjective manual assessments of land unit suitability/capability will increase proportionately with the accumulation of specific wildlife habitat-use research information. It is important, therefore, that research gaps in the field of wildlife habitat-use within the context of ELS be identified and filled.

It is not advisable to use subjective assessment by species experts as a single measure of land unit importance. Possible exceptions include: 1) when mapping scales are smaller than 1:500,000, and; 2) if a very simple two- or three-tiered evaluation rating system is used. Subjective evaluations of land unit importance can be improved considerably by supplying the species experts with current field data from the survey area. In addition, the repeatability of subjective assessments may be enhanced by using a standardized rating system geared to the habitat attributes of the biophysical legend.

Currently, the ability of plant and soil/landform ecologists to classify and map biophysical features exceeds the capability of wildlife biologists to subjectively assess their relative value, without the aid of field data. As the body of habitat-use research information grows, this disparity will lessen and the effectiveness of subjective assessments will improve.

C. Modelled Assessments

The preceding paper by Stelfox on wildlife resource evaluation reviews the techniques and pros and cons of modelled assessments of land unit importance. This approach is relatively new and in the process of evolution and refinement. Modelled assessments of land unit importance have considerable potential, especially in terms of introducing objectivity and repeatability to the evaluation process. There is, however, a definite need for validation of modelled assessments. This can only be accomplished through rigorous subjective assessments and medium to long term, well designed and properly stratified field data collection. As such, it is recommended that any modelled evaluation of land unit importance be accompanied by subjective assessment and field surveys.

RECOMMENDATIONS

The evaluation of wildlife resources within Ecological Land Surveys is a relatively new and evolving process. The following points summarize some of the author's principal concerns and recommendations for future improvements:

1. It is important that for species with large home ranges, such as ungulates and some carnivores, that we assess how land unit juxtaposition influences habitat use. Certain combinations of land units may "synergistically" enhance the value of one another for certain wildlife species. Research-oriented studies are necessary to provide this sort of information. These studies should be conducted in representative ecoregions such that extrapolations to other localities within regions can be made.

2. An attempt should be made to collect and organize information as to what are effective and realistic mapping scales for evaluating land unit importance for different species of wildlife. This information would be highly useful for land planners who are considering using ELS.

3. It is important that habitat biologists communicate fully with population biologists and behavioral ecologists when evaluating land unit importance. For many species, factors other than habitat (e.g., human disturbance) are primary influences or current land use (e.g., grizzly bear, wolves and caribou).

4. More ELS's should include a component that predicts successional pathways of vegetation types, that can be implemented at the map unit level. This would be an extremely useful tool for predicting wildlife responses to habitat manipulation and enhancement.

5. It is vital that wildlife biologists recognize the importance of long-term research studies in refining and validating wildlife assessments within

ELS. Short-term field inventories will never be able to confidently confront such problems as use of juxtaposed land units, the importance of vegetation strata diversity, relative seasonal importance of land units, the influence of ecotone or interspersion, or refinement of variable rankings for computer modelled assessments.

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DISCUSSION GROUPS / GROUPES DE DISCUSSION

DISCUSSION GROUPS

Group 1:

Chapter 3:
Theoretical Basis for Integrating Wildlife Resource Assessment and Ecological Land Survey.

Group Tasks:

- review the relevance of material to the overall objectives and content of the manual;
- review the consistency of guidelines in chapters 4 and 5 with the ecological theory; and
- review means and ways of translating this theory into practice.

Overall, it was felt that the paper was good, but that it was not extensive enough and did not adequately provide the basis for completing the manual.

Recommendations:

1. The theory paper should be incorporated into the manual. It will serve as the real bridge between theory and application. By incorporating the entire paper, the readers will obtain an understanding of the implications of ecological theory to ELS and the application of ecological theory to wildlife population management. The paper should contain a comprehensive list of references (for additional reading). It should also address limiting factors in the context of how they effect biogeographical theories.

2. The theory paper is primarily oriented to terrestrial wildlife. Where possible, some fisheries examples should be incorporated throughout.

3. Ecological Land Survey should be applied in the context of faunal communities. This concept might best be incorporated into chapter 4. It is recommended that we upgrade the faunal community relationships discussion, identify the faunal community "provinces" or "regions", and examine the identification process in the context of ELS. Scale might also be addressed in chapter 4.

4. Chapters 4 and 5 should be reviewed for consistency with the theory chapter. There was some inconsistency in the way issues were being represented in 4 and 5 (e.g., the statement referring to habitats as 'detractions', when habitats do not necessarily detract).

5. Information systems theory should be described as part of the information system models which are described in the manual. There should be a short text on models and then a few pages with figures describing information processing. This particular section might be enhanced with a short dissertation on theory.

Group 2:

Chapter 4:
Incorporating Wildlife Resource Values into Ecological Land Surveys.

Group Tasks:

- review the relevance of material to the overall objectives and content of the manual;
- review the chapter with reference to:
  - completeness;
  - duplication/redundancy;
  - examples applicable to all wildlife types and areas of the country;
  - logical sequencing (order of sequence and timing);
  - "practicalities" related to content; and
  - duplication and continuity with respect to other sections.

Recommendations:

1. The chapter provides considerations rather than practical techniques. Although a few techniques were listed late in the chapter, the techniques should not be stressed in the objectives because they really were not an integral part of the chapter.

2. The objectives in chapter 2 should be revised.

3. Overall, the chapter fit well into the context of the manual outlining ELS and wildlife. As far as the content of the chapter, it is useful to recap ELS. The table of contents should include the sub-headings that were part of that chapter, so that items could be more easily located.

4. In a number of cases, the BC manual, which includes detailed sampling forms for a number of different things, should be given as examples where it was indicated that examples do not exist.

5. The list of possible techniques needs to be added to. In conjunction with this, listing what the techniques could be used for would be a useful addition to that table. The group did not feel that it was appropriate in this type of manual to go into detail about techniques; rather, a comprehensive list of references would be worthwhile, so that sources for the techniques could be easily located. Anybody using the techniques should ensure that they are well documented.

6. In general, the examples in chapter 4 could be diversified and include a wider range of species, including the various regions of Canada. We felt that an integral part of the introduction of the chapter could be linking scale with wildlife evaluations. That would set a framework for understanding how well evaluations and integration of wildlife and ELS could be done. In the table on page 18, more detail could be provided for the faunal component descriptive context for each scale. Although it is not appropriate to modify that table, which is an existing published table, using the type of framework (the type of evaluations) that would be appropriate for each scale could possibly be included. For instance, it may not be appropriate to analyse all aspects of moose habitats at equal levels of detail. This could use more clarification so that the proper level of information was collected and the proper evaluations were done at each scale. With respect to field data sheets, it was suggested that data sheets be computer compatible whenever possible to aid our process along.

Group 3:

Chapter 5:
Using Land/Wildlife Relationship Models and Ecological Land Surveys to Aid the Evaluation of Wildlife Surveys.

Group Tasks:

- review the relevance of material to the overall objectives and content of the manual;
- identify content that may not be useful as well as information/guidelines that are needed but are currently missing; and
- review the balance and completeness of presentation with respect to representative wildlife types and sequencing of material.

Recommendations:

1. There needs to be a broader range of species in the examples and also a better range of examples from different regions in Canada. Under the first portion, for population status, there needs to be a discussion of how the **critical areas** or **key wildlife areas** concept can fit into ecological land surveys.

2. There needs to be some discussion of **carrying capacity estimates**, or what in Alberta is called **expected population densities**. This can probably be correlated to **inherent habitat capability** or **potential habitat capability**. Under habitat assessment, we need much clearer definitions of what **current habitat suitability** and **inherent habitat capability** are. What we really need there are operational definitions that people can use when they go out into the field or when they try to apply things. There needs to be some discussion of where the different definitions should be used and for what purposes. Under multiple species occurrence, there needs to be an explanation that the definition of guild should be the applied definition rather than the pure research definition. In 5.2 ("Land/Wildlife Relationship Models"), in the introduction it should be noted that in Canada, our models are simply structured subjective assessments. They are not objective, quantified models, they are simply a way of structuring a subjective assessment so that it can be repeated. It should also be noted that the modeler should be introduced into the process at the same time that the land survey mapper is introduced. That way, the data base that is prepared will be appropriate for the modeling task. In 5.2.3 ("Model Structure and Operation"), the complexity of the variables that are chosen should reflect the mapping scale; to that end, variables can be structured in a hierarchical fashion. Broad overstory characteristics of vegetation can be dealt with at 1:50 000 scale, whereas various modifiers in terms of species composition and density can be considered at larger scales. Some pictorial examples of this kind of would enhance the final document.

3. The terms listed on page 77 should be explained (e.g., word models, mechanistic models, and Bayesian probability models).

4. On page 81, we need some reference to the size of habitat patch under interspersion.

5. Under 5.2.4 ("Documentation and Validation"), the concept that population data need not necessarily reflect habitat suitability should be discussed in more detail. There should also be a discussion of the problems associated with using the opinion of species experts to validate the model assessments. Those problems include differences among experts. Also, there is a problem with circularity of the argument (i.e. the species expert often reviews the model; if he also provides the manual assessment to it, it may not be surprising if the results are the same). A possible solution to the problem of validation includes an iterative process using different assessment methods, or using the same assessment method in slightly different ways.

6. Some recent publications do indicate that habitat use should be a good reflection of habitat suitability, although that may not be the case in very large study areas. The notion is worth pursuing. Also, the sections on documentation of the model and validation of the model should be separated.

7. In 5.3 ("Selecting the Best Land Attributes as Predictors of Wildlife Resource Values"), it should be emphasized that what is in the document is simply guidelines, and that each specific person is going to have specific things that they are going to have to select, and that will depend on the wildlife species that they are concerned with as well as their own objectives. In that regard, the list of variables cannot be comprehensive, but rather should be used to stimulate thought processes. Table 3 should be stratified by the type of habitat variables as well (e.g., standing water, flowing water, terrestrial, marine, and climate variables). The long and detailed section called "Vegetation versus other parameters" tends to "over sell" the ELS process to people who are possibly already sold on it; perhaps the detail in the introduction could be reduced.

8. In 5.3, table 5 could be "fleshed out" more, particularly with what is possible using remote sensing (what we can do using remote sensing and what we cannot do). We also need to better define what interspersion really means and how it can be applied in the methods that can be used to measure it.

Group 4:

Chapters 1, 2, 4.5, and 5.5:

Group Tasks:

- review the overall scope, organization, purpose, and objectives of the manual;
- review and discuss client (inventory people) needs for this guidelines manual and identify strengths and weaknesses of the current scope and content; and
- review and identify marketing strategies for the land use planner and wildlife manager.

Recommendations:

1. This manual basically is intended to help "producers" of resource information develop more standardized products and possibly to market that information. Within the purpose on page 2, there should be a note on making the information available within a "marketing" mandate.

2. Chapter 5.5 ("Meeting the Wildlife Manager's Needs") needs expansion and should be in one direction relating to how to make the information meet the user's needs. Target groups should be brought into the project and their needs identified. It is important to work with them and consult with them to ensure that their needs are met. It is also important to help them use those products. Products should be kept simple.

RECOMMENDATIONS FROM PLENARY SESSIONS

1. The survey persons (i.e. those who are creating the survey products) should also be actively involved in assisting their clients, the management decision-makers, in applying that data and information.

2. The "Bibliography" should include wildlife and fisheries inventory techniques manuals. The bibliography and references to the detailed field techniques manuals should serve the purpose of covering off that fairly detailed technical level of information need (i.e., there are many existing technical manuals which need only to be referred to; we do not need to redo what they have already covered). The manual could be more of a working framework (i.e., more of a general nature) than a "detailed techniques" manual; short documentation on new technologies should suffice.

3. The manual should initially be published as a "first approximation". The practicality, usefulness, and workability of it will have to be evaluated via feedback from users of it. As such, the manual will have to evolve over time. Calling it a first approximation will more easily leave the manual open for change (i.e., readers will be aware that it is not the ultimate product, but rather the "state of the art" in the evolutionary sequence of the development of a "final manual").

4. There should be a stronger link between the Wildlife Working Group and the Vegetation Working Group. At some point it may also be worthwhile to have a comprehensive workshop where all working groups of the CCELC can interact.

5. For review comments on the draft manual, the private consulting industry should be considered as they will be one of the clients; they may be interested in doing something on a voluntary basis solely for the business development. The academic community should also be able to provide excellent review comments.

GROUPES DE DISCUSSION

Groupe 1 :

Chapitre 3 : Base théorique pour l'intégration de l'évaluation des ressources fauniques et du relevé écologique des terres (RET).

Tâches du groupe :

- vérifier la pertinence de la matière incluse par rapport aux objectifs globaux et au contenu du manuel;
- vérifier si les lignes directrices contenues dans les chapitres 4 et 5 sont conformes à la théorie écologique; et
- examiner les moyens d'appliquer cette théorie à la pratique.

Dans l'ensemble, on a jugé que le document était valable mais que le sujet n'était pas suffisamment développé et ne fournissait pas la base nécessaire pour compléter le manuel.

Recommandations :

1. L'exposé théorique devrait être incorporé au manuel pour servir véritablement de lien entre la théorie et son application. L'incorporation de tout le document permettra de discuter des conséquences de la théorie écologique pour le RET, et de son application à la gestion des populations fauniques.

Le document devrait contenir aussi une bibliographie exhaustive pour les besoins du lecteur. Il devrait aussi traiter des facteurs limitatifs et de leurs effets sur les théories biogéographiques.

2. L'exposé théorique est avant tout orienté vers la faune terrestre. Lorsque cela est possible, des exemples sur les pêches devraient y être incorporés ici et là.

3. Le relevé écologique du territoire devrait être appliqué dans le contexte des communautés fauniques. Ce concept aurait sans doute avantage à être incorporé dans le chapitre 4. On devrait améliorer la discussion des relations entre les communautés fauniques, identifier les provinces ou régions des communautés fauniques et examiner le processur d'identification dans le contexte du RET. Il pourrait aussi être question d'échelle au chapitre 4.

4. Il faudrait s'assurer en les vérifiant que les chapitres 4 et 5 correspondent au chapitre sur la théorie. Il existe une certaine incohérence dans la façon avec laquelle les questions ont été traitées dans ces deux chapitres (p. ex. où il est question de "detractions" (facteurs d'amoindrissement) en parlant des habitats, alors que justement ceux-ci ne sont pas particulièrement nuisibles).

5. La théorie des systèmes d'information devrait être décrite en même temps que les modèles de systèmes d'information exposés dans le manuel. Il devrait y avoir un texte cours sur les modèles puis quelques pages avec des figures illustrant le processus d'information. Cette section en particulier pourrait être accompagnée d'un texte succinct sur la théorie.

Groupe 2 :

Chapitre 4 : Incorporation des valeurs fauniques dans les relevés écologiques des terres.

Tâches du groupe :

- examiner la pertinence de la matière par rapport aux objectifs globaux et au contenu du manuel;

- examiner le chapitre pour voir:

  - si elle est complète;
  - si elle fait double emploi ou si elle est redondante;
  - si elle contient des examples applicables à tous les types et régions fauniques du pays;
  - si elle se présente dans une succession logique (ordre séquentiel et à-propos);
  - si elle s'avère praticable par rapport au contenu; et
  - s'il y a répétition ou continuité par rapport aux autres sections.

Recommendations :

1. Le chapitre contient des considérations plutôt que des techniques d'ordre pratique. Bien que quelques techniques soient énumérées à la fin du chapitre, elles ne devraient pas être soulignées dans les objectifs parce qu'elles ne font pas partie intégrante du chapitre.

2. Les objectifs du chapitre 2 devraient être réexaminés.

3. L'ensemble du chapitre figure bien dans le cadre du manuel pour souligner le RET et la faune. Quant à l'utilité du chapitre, il fait le point sur le RET. La table des matières devrait présenter les sous-titres de ce chapitre pour que les points soient plus facilement repérés.

4. Dans certains cas, le manuel de la Colombie-Britannique contenant des formules d'échantillonnage détaillées pour plusieurs aspects différents pourrait servir d'exemple là où on indiquait qu'il n'en existait pas.

5. La liste des techniques possibles devrait être étoffée. Dans cet ordre d'idées, l'énumération des différentes utilisations des techniques pourrait être un ajout utile à ce tableau. Nous n'avons pas l'impression qu'il soit approprié dans ce genre de manuel d'entrer dans les détails concernant les techniques; par contre, une bibliographie exhaustive serait appréciable, parce qu'elle permettrait à l'utiliser de se documenter facilement sur les techniques. Quiconque utilise celles-ci doit s'assurer qu'elles font toutes l'objet d'une bonne documentation.

6. D'une manière générale, les exemples de ce chapitre pourraient être diversifiés et comprendre un éventail plus large des espèces, provenant des diverses régions du Canada. Nous croyons que l'essence de l'introduction du chapitre pourrait consister à exposer le lien entre les questions d'échelle et les évaluations de la faune. Cela établirait une structure permettant de comprendre avec quel degré de succès les évaluations et l'intégration de la faune et du RET pourraient être réalisées. Dans le tableau de la page 18, on pourrait fournir davantage de détails sur le contexte descriptif de l'élément faunique à chaque échelle. Même s'il ne convient pas de modifier ce tableau, qui en fait a déjà été publié, le type de structure (type d'évaluations) convenant à chaque échelle pourrait probablement être inclus. Par exemple, il peut ne pas être approprié d'analyser tous les aspects de l'habitat de l'original avec autant de détails dans tous les cas. Ce point aurait avantage à être clarifié pour que la quantité d'informations appropriées soit recueillie et que des évaluations adéquantes soient effectuées à chaque échelle. Concernant les fiches de données techniques sur le terrain, on a proposé qu'elles soient utilisables sur des ordinateurs dans toute la mesure du possible pour faciliter le traitement.

Groupe 3 :

Chapitre 5 : Utilisation des modèles de relations terre/faune et les relevés écologiques du territoire pour faciliter l'évaluation des inventaires de la faune.

Tâches du groupe :

- examier la pertinence de la matière par rapport aux objectifs globaux et au contenu du manuel;
- repérer le contenu qui peut ne pas être utile de même que l'information et les lignes directrices qui seraient nécessaires mais qui font actuellement défaut; et
- vérifier si la présentation est équilibrée et ocmplète par rapport à des types fauniques représentatifs, et examiner l'ordre de succession du matérielé

Recommendations :

1. D'abord, les exemples doivent offrir un éventail plus large des espèces et des différences régions du Canada. Dans la première partie, en ce qui a trait à l'état de la population, il doit y avoir une discussion sur la manière d'adapter au relevé écologique des terres les régions critiques ou les régions fauniques clés.

2. Il est nécessaire de discuter des évaluations de peuplement, ou de ce que en Alberta on nomme densitée de population prévues. Un parallèle peut probablement être établi avec la capacité d'habitat inhérente ou la capacité d'habitat potentielle. Au chapitre de l'évaluation de l'habitat, il doit y avoir des définitions plus claires de convenance de l'habitat actuel et de capacité d'habitat inhérente. En réalité, il faut ici des définitions opérationnelles que les utilisateurs peuvent employer quand ils vont sur le terrain ou font des applications. Il faudrait discuter pour savoir où les différentes définitions peuvent être utilisées et à quelles fins. Dans les cas d'espèces multiples, il faudrait expliquer que la définition de "guilde" devrait être la définition appliquée de préférence à la définition de la recherche pure. Dans l'introduction de 5.2, qui porte sur les modèles de relations entre les terres et la faune, il convient de noter qu'au Canada nos modèles sont tout simplement des évaluations subjectives structurées. Ils ne sont pas objectifs, ils ne sont pas quantifiés et repréentent simplement un moyne de structurer l'évaluation suggestive pour qu'elle puisse être répétée. Il convient aussi de noter que le concepteur du modèle devrait intervenir dans le processus en même temps que la personne effectuant le relevé des terres, de façon à ce que la base des données préparée convienne au travail de modélisation. Dans le 5,2,3, qui porte sur la structure et l'utilisation des modèles, la complexité des variables choisies devrait refléter l'échelle cartographique; pour ce faire, les variables peuvent être structurées de manière hiérarchique. Sur le plan de la végétation, les grandes caractéristiques de l'étage dominant peuvent être traitées à l'échelle de 1:50 000, tandis que les différents modificateurs de la composition et de la densité des espèces peuvent être considérés à de plus vastes échelles. Certains exemples graphiques de cette sorte amélioreraient le document final.

3. Les termes de la page 77 (modèles, modèles mécanistes, modèles de probabilité "bayesiens" devraient être expliqués.

4. A la page 81, il faut des indications sur la dimension de l'habitat au moment de l'insertion d'une espèce au sein d'une communauté écologique.

5. Dans le 5,2,4, qui traite de la documentation et de la validation, le concept selon lequel les données de population n'ont pas forcément à refléter la convenance de l'habitat devrait aussi être discuté plus en détail. Il devrait également y avoir une discussion sur les problèmes qu'entraîne le recours à l'opinion des spécialistes en matière d'espèces pour valider les évaluations des modèles. Ces problèmes incluent les divergences entre spécialistes. Mais il y a également un problème de circularité de raisonnement, c'est-à-dire, que si le spécialiste vérifie souvent le modèle et qu'en plus il fait l'évaluation du manuel, il n'y aura pas lieu de s'étonner si on obtient les mêmes résultats. Un solution possible au problème de la validation pourrait résider dans un processur itératif utilisant différentes méthodes d'évaluation, ou d'utilisant la même méthode d'évaluation de façon légèrement différente.

6. Des publications récentes indiquent que l'utilisation de l'habitat devrati être un bon reflet de son utilisabilité; bien que cela puisse ne pas être le cas dans les

très grandes régions étudiées, cette notion mérite d'être approfondie. De plus, les sections sur la documentation du modèle et sur sa validation devraient être séparées.

7. Dans le 5.3, qui porte sur le choix des meilleurs attributs terrestres comme variables indicatrices des valeurs fauniques, il importerait de souligner que le document contient simplement des lignes directrices et que chaque personne aura un choix à faire selon les espèces fauniques dont elle s'occupe aussi bien que ses propres objectifs. A cet égard, les listes des variables ne sauraient être exhaustive mais peuvent servir à stimuler la réflexion. Le tableau 3 devrait être stratifié selon les types d'habitat ainsi que d'autres variables comme l'eau dormante, l'eau courante, les variables terrestres, les variables marines et les variables climatiques.

8. La section longue et détaillée portant sur la végétation par rapport à d'autres paramètres tend à exagérer les mérites du processus de RET auprès de personnes qui sont probablement déjà gagnées à cette idée; le niveau de détail de l'introduction pourrait probablement être réduit.

Dans le chapitre 5.3, le tableau 5 pourrait être élaboré davantage, notamment à propos de ce qui est possible sur le plan de la télédétection (ce qui peut et ne peut être fait avec cette technique). Nous devons également mieux définir ce que signifie l'insertion des espèces dans une communauté écologique et comment on peut l'appliquer dans les méthodes qui peuvent être utilisées pour la mesurer.

Groupe 4 :

Chapitre 1, 2, 4, 5 et 5.5 :

Tâches du groupe :

- examiner l'objectif global, l'organisation, le but et les objectifs du manuel;
- examiner et discuter les besoins du client (en charge de l'inventaire) à l'égard de ce manuel de lignes directrices et identifier les points forts et les lacunes de l'objectif et du contenu actuel;
- examiner et repérer les stratégies de commercialisation pour le planificateur de l'utilisation des terres et le gestionnaire de la faune.

Recommendations:

1. D'abord et avant tout, ce manuel a pour but de permettre aux "producteurs" d'information sur les ressources de normaliser davantages leurs produits et probablement de commercialiser cette information. Dans l'objectif en page 2, il devrait y avoir une note concernant la possibilité de rendre l'information accessible dans un cadre de "commercialisation".

2. Le chapitre 5.5, qui porte sur les moyens de satisfaire les besoins des gestionnaires de la faune, doit être étoffée et exposer la manière de procéder pour que l'information réponde aux besoins des utilisateurs. On recommande d'introduire des groupes cibles dans le projet pour que leurs besoins puissent être identifiés. Il est important de travailler avec eux et de les consulter si l'on veut que leurs besoins soient satisfaits. Il importe également de les aider à utiliser ces produits, lesquels doivent rester simples.

RECOMMANDATIONS DES SÉANCES PLÉNIÈRES

1. Les personnes chargées d'effectuer les relevés, c'est-à-dire lea créateurs du produit doivent également aider activement leurs clients, les décideurs, à appliquer cette information.

2. La "Bibliographie" doit inclure les manuels techniques sur la faune et les manuels techniques sur l'inventaire des pêches. La bibliographie et les renvois aux manuels techniques doivent servir à répondre aux besoins d'information à un niveau technique (c'est-à-dire qu'il n'y a qu'à consulter les nombreux guides techniques existants sans qu'il soit nécessaire de refaire toute la même démarche). Le manuel pourrait être davantage une structure de travail (de nature générale) qu'un ouvrage exposant des techniques détaillées; une brève documentation sur les nouvelles technologies devrait suffire.

3. Au départ, le manuel devrait être publié comme une "première tentative". Son côté pratique et utilitaire devra être évalué d'après la réaction des utilisateurs. Le manuel sera ainsi appelé à évoluer avec le temps. En qualifiant le manuel de "première tentative", il sera plus facile de le laisser accessible aux modifications (le lecteur étant averti qu'il s'agit non pas d'un produit figé mais plutôt d'un ouvrage représentant le meilleur effort actuel en vue d'une version définitive).

4. Le lien entre le Groupe de travail sur la faune et le Groupe de travail sur la végétation devrait être raffermi. Dans un sens il y aurait également intérêt à former un atelier où tous les groupes de travail du CCCET pourraient intervenir.

5. Étant donné qu'ils feront partie des clients, l'opinion des experts-conseils du secteur privé devrait être prise en considération dans l'examen de l'ébauche du manuel; ils peuvent être intéressés à fournir une contribution volontaire uniquement pour le progrès de ce secteur d'activités. Le monde universitaire devrait aussi être en mesure de fournir d'excellentes remarques.

SUMMARY PRESENTATIONS/RAPPORTS SOMMAIRES

SOME OBSERVATIONS OF ONE OF THE NEW CO-CHAIRMEN (PAUL GRAY) OF THE WILDLIFE WORKING GROUP (WWG)

1. The CCELC is one of the few committees where the vast majority (if not all) of the participants want to belong and be active.

2. The expertise in the WWG is impressive.

3. The Committee itself has momentum -- the work of the committee is progressive, meaningful, and exciting.

4. The Committee "enjoys" excellent financial, logistical, and technical support from the federal government.

These are some of the reasons which influenced my decision to get more actively involved in the WWG. At the time of the meeting, the primary question in my mind was how to retain these qualities, and how to build on them -- build on them in the context of work we are doing, in the context of the people in the membership, and in the context of generating momentum to enhance our experience and expertise. Two major thrusts drive the WWG. The first is the administrative maintenance of the Group for which the co-chairmen are primarily responsible. We will function as facilitators who manage the administration of the Group. The second thrust, and probably the more important one, focusses on the concepts of desire, interest, momentum, and involvement. If we are to enjoy continued success, we must build on past accomplishments of the Group. Only the membership can do it; the co-chairmen will provide the mechanism for it.

With respect to the future of the WWG, three general concepts warrant discussion:

1. Promotion -- we must improve the way we sell ourselves as a professional organization.

2. Idea generation -- we should try to tap the imagination of the WWG membership.

3. Program development and implementation.

Under the "promotion" category, the Group might want to consider the development of a pamphlet which briefly highlights who we are and what we do. Such a pamphlet might best be developed by one person, with input and feedback from the other members of the Group. The pamphlet prepared for the Canadian Council on Ecological Areas might serve as one example to consider.

Considerations include:

1. The pamphlet would be printed in both official languages (translation, French typesetting, French editing, etc. could be handled through the CCELC Secretariat).

2. If the text cannot be prepared by a member of the WWG (due to time constraints), we may want to sponsor its completion via a contract.

3. As to format, we are likely looking at a single sheet of paper, or perhaps two sheets folded to fit in a standard envelope. The text should be concise and the content carefully selected. Contacts could be noted where the reader could get more detail on areas of interest (e.g., the co-chairmen of the WWG or the CCELC Secretariat).

4. A less expensive alternative to a "glossy" pamphlet is a "fact sheet" (e.g., the Lands Directorate's Land Use Change in Canada "fact sheets", and Environment Canada's "science briefs" on the Long Range Transport of Airborne Pollutants, the Canadian Wildlife Service's Hinterland Who's Who series, or the Wildlife Notes of the Government of the Northwest Territories).

I also recommend that we consider the production of a poster display which describes the WWG and the activities of the membership. The poster would be useful at various wildlife/fisheries and environmental forums which are held on a regular basis across the country.

Another idea that I put forward for consideration is the integration of fisheries and wildlife interests into one Working Group. This would involve changing the name and the perspective of our Working Group in an effort to broaden the depth and interest of the Group. It is an idea requiring consultation and planning. We will attempt to address this issue during our term as co-chairmen.

During the next few years, emphasis will be placed on the development and completion of the "Manual of Guidelines for the Integration of Wildlife Resource Assessment with Ecological Land Surveys." Harry Stelfox, as senior editor, will coordinate this initiative on behalf of the Group. This document will fill a large void in Canada, and will be useful to managers and researchers.

In summation, I feel that the members of the Wildlife Working Group have made considerable progress in the last few years. As co-chairman, I will strive to ensure that this momentum is maintained and that we attain our goals and objectives. Our continued success is contingent upon the interest and participation by all involved.

QUELQUES OBSERVATIONS DE PAUL GRAY, L'UN DES NOUVEAUX COPRÉSIDENTS DU GROUPE DE TRAVAIL SUR LA FAUNE (GTF)

1. Le CCCET est l'un des rares comités auquel la majorité sinon la totalité des membres tient à appartenir tout en y agissant concrètement.

2. La compétence du GTF est impressionnante.

3. Le Comité a pris son élan -- son action est orientée vers le progrès, elle est significative et stimulante.

4. Le gouvernement fédéral offre au Comité un excellent soutien financier, logistique et technique.

Voilà quelques-unes des raisons qui ont influé sur ma décision de participer davantage au GTF. Au moment de la rencontre, la première question que j'avais à l'esprit portait sur le moyen de conserver ces qualités et de construire autour d'elles -- construire en termes de la tâche que nous sommes en train d'accomplir, en cherchant à accroître la participation peut-être, ou en ouvrant au groupe des avenues nouvelles. Deux aspirations majeures animent le GTF.

La première vise l'aspect administratif, et je présume que les coprésidents sont d'abord et avant tout responsables de cet élément. Nous serons office de facilitateurs qui assurent l'administration du Groupe. La seconde aspiration, sans doute la plus importante, porte sur le désir, l'intérêt, l'entrain et la participation. Si nous voulons continuer sur la voie du succès, nous devrons bâtir sur les réalisations du Groupe.

Seuls les membres peuvent y parvenir; les coprésidents assureront le mécanisme.

Concernant l'avenir du GTF, trois concepts généraux méritent d'être discutés :

1. La promotion -- Nous devons améliorer notre façon de vendre nos services en tant qu'une organization professionnelle.

2. La production d'idées nouvelles -- Il faut soliciter l'imagination des membres du GTF.

3. L'élaboration et la mise en oeuvre du programme.

Au chapitre de la "promotion", le Groupe pourrait envisager la publication d'un dépliant exposant brièvement ce qu'il est et ce qu'il fait. Ce dépliant aurait sans doute avantage à être rédigé par une seule personne qui soliciterait les remarques et les réactions des autres membres du Groupe. Le dépliant préparé pour le Conseil canadien des aires écologiques pourrait servir d'exemple.

À ce chapitre, il y aurait lieu de tenir compte des considérations suivantes :

1. Le dépliant devrait être publié dans les deux langues officielles (la traduction, la composition, etc. de l'édition française, seraient exécutées sous la responsabilité du secrétariat du CCCET).

2. Si, faute de temps, le texte ne peut pas être rédigé par un membre du GTF, on pourrait envisager d'en confier la rédaction à contrat.

3. Pour ce qui est du format, nous prévoyons probablement une simple feuille de papier, ou peut-être deux, pliée qui irait dans une enveloppe de taille normale. Le texte devrait être concis et le contenu soigneusement choisi. Il conviendrait d'indiquer au lecteur les points de contact où il pourrait obtenir plus de détails sur les domaines d'intérêt (p. ex. les coprésidents du GTF ou le secrétariat du CCCET).

4. Une autre solution moins coûteuse qu'un dépliant sur papier glacé est un feuillet d'information, dont nous avons des exemples avec Évolution de l'utilisation des terres au Canada publié par la Direction générale des terres et avec les feuillets d'information scientifique sur le Transport à grande distance des polluants atmosphériques, ou la série du Service canadien de la faune intitulée La faune de l'arrière-pays, ou avec les notes sur la faune que publie le gouvernement des Territoires du Nord-Ouest.

Toujours dans le même ordre d'idées, on pourrait faire imprimer un panneau d'affichage décrivant le GTF et ses activités. On pourrait l'utiliser lors des forums de chasse et pêche, comme il s'en produit dans tout le pays.

Une autre des possibilités envisagées est l'intégration complète de la pêche et de la faune dans le Groupe. D'après cette solution il faudrait sans doute modifier le nom du groupe ainsi que toute la perspective en essayant d'élargir le champ d'activité et les intérêts du groupe. C'est une possibilité qui aura besoin de consultation et planification. Nous allons essayer d'y adresser pendant notre durée comme coprésidents.

Pendant les années suivantes, on mettra l'accent sur le développement et la réalisation du "Manuel de lignes directrices pour l'intégration de l'évaluation des ressources fauniques avec les relevés écologiques du territoire". Harry Stelfox, l'éditeur principal, sera le coordonnateur pour le compte du Groupe. Ce document remplira un grand vide au Canada et il sera utile aux gestionnaires et aux chercheurs.

En somme, je crois que les membres du Groupe de travail sur la faune ont fait des progrès digne de considération, pendant les années récentes. Comme coprésident, j'essayerai d'assurer que cet élan poursuit et que nos buts et objectifs soient réalisés. Notre succès soutenu dépend de l'intérêt et de la participation de tous les intéressés.

WORKSHOP SUMMARY

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The principal reason for the workshop was to facilitate the exchange of ideas. There were also specific objectives, which were to be addressed in the first day's presentations, in group discussions, and in informal discussions. I attempted to examine, through positive criticisms, whether these objectives were met. The following are some general observations that I have made.

On the first day, some recent advances in technology, methods, and applications were discussed. I would like to relate such advances to what I call the "band wagon curve", which can be applied to anything new, such as recent satellite technology and new approaches to ecological modelling. When something new is introduced, everyone "gets on the band wagon", thinking that perhaps it will answer all their questions. At some point, however, they realize that it will not answer all of them. Ecological modelling is a good example. People in environmental impact assessment have given us models to predict what the impacts will be. However, such models have tended to raise more questions and identify problematic variables, such that many people got "turned off" by ecological modelling. The same thing applies to satellite technology for assessing wildlife habitats -- the technology does all the work for you and it can be explained to anyone. There are some difficulties, however, some of them technical (the canopy, the water surface, small areas, etc.). Satellite technology provides an excellent tool, but it must be applied at the proper level, and I think that we are realizing that. I am not sure where on the curve we stand now, but eventually it will stabilize and people will use the technology with suitable funding, properly trained personnel, proper equipment, appropriate methods, etc. for reliable and efficient habitat assessments.

This discussion has not really related to a wildlife issue, but more to a people issue. In fact, in wildlife resource management, probably 90% of the problems are people problems. With this in mind, I would like to suggest that for future meetings or workshops, we should invite at least one person specializing in people issues, such as a sociologist or a psychologist, to give us that kind of a perspective.

With respect to discussions regarding a possible brochure, we are still far too vague. We do not have a clear focus for the brochure. We need a specialist for that -- we need to tell him what we want so that the product prepared will adequately speak for us.

The posters at the meeting were of an excellent quality and put in evidence the complex versus the simple situation. In approach, in methodology and even in the ultimate product itself, some were very simple, whereas others were so complex that they required considerable explanation. The posters did not address certain things: for example, there were no posters on ecotones, there was very little on the land/water interface, and recognizing "critical habitats" was not well addressed (this is a key thing in land use planning -- a critical habitat has to be recognized rather readily).

I would now like to make some observations regarding the manual of "Guidelines for the Integration of Wildlife Resource Assessment with Ecological Land Survey". In all, four presentations were made in plenary session. Tom Hoekstra's presentation of ecological theory provides an excellent base for the manual. It gives soundness to the habitat classification and creates some form of hierarchy. It gives some validity to the wildlife issue.

John Kansas noted several concerns that he had, such as vegetation succession. What is going to happen after the habitat has been classified? Will changes occur quickly or only over the long term? If the habitat changes quickly, there could be problems with the classification.

Concerns such as this must be addressed by experts, such as the membership of the Wildlife Working Group.

The other two presentations dealt with objectives, scope, and methodology. My overall impression was that all sections of the draft manual had been well prepared, especially considering the need to have such a draft ready for discussions at the meeting.

As far as the group discussions about the manual, members were generally very active and enthusiastic. Unfortunately, some of the discussion group members were unable to prepare for the discussions as well as they would have liked, having received their copy of the draft manual just a few days prior to the meeting.

I have seven points now that are rather personal, and I will try to encompass the whole thing. I will develop some thoughts here, but perhaps everyone should do the same on their own later.

1. The first point is complexity versus simplicity. This came up several times at the meeting. It is difficult to think how to reconcile the "keep it simple" approach with the fact that the environment, and hence any ecological land classification to characterize it, is quite complex. There are generally many variables and values associated with any ELC. Tom Hoekstra, in his slide presentation, listed resource parameters for virtually sixty minutes non-stop. There are many variables, but perhaps some could be excluded (i.e. more caution in selecting variables). We should also watch for relationships that are of the cause-and-effect nature.

2. The second point that I would like to consider is ecotones -- all kinds of ecotones, including land/water interface and any kind of mixed habitats. In terms of land use, the ecotone is a very important land unit. The manual stated that biophysical analysts tend to avoid ecotones, and the poster papers did not seem to address this habitat. Ecotones should be a high concern to us because they can be critical as prime wildlife habitats. If we always shy away from them, we will never get a true picture of what we want to do for the ultimate fate of wildlife. Ecotones will have to be addressed by this group sometime, otherwise we will definitely be open to outside criticism on that point.

3. We have generally had limited input from fisheries in the working group. Fisheries people are contacted and they do express interest in the group. If nothing else, we should be able to handle the riparian zone. We were fortunate at the workshop to have had posters on the stream habitat, so that is a step in the right direction. Apart from spawning grounds as critical fish habitats, there seems to be little to go on in the aquatic environment compared to terrestrial habitats. That is a definite weakness that we have to address somehow. A suggestion might be to have a workshop specifically to address the fisheries issue and/or the aquatic environment.

4. Another item is the size of habitat units, which also raises the question of diversity. Tom Hoekstra addressed that one very well. We have to think that diversity is good, but also the fact that some species need large tracts of fairly homogeneous land. We therefore must think in terms of "how large should these tracts of land be?

5. A fifth point relates to conservation of habitat units. Working with small pockets of habitats in the Montreal area, I am often questioned by planners as to which ones should we keep. I see a few marine biologists saying "keep them all". That does not go over too well when you add the grandiose concepts of development areas. Planners also ask questions such as, "If we cannot touch it, how close can we get to it"? I cannot answer that.

6. There was considerable discussion about marketing and about input from the client (e.g. land use planners). In a normal contractual situation, the client writes the terms of reference; for this reason, I think that land use planners or other "clients" should have been at the workshop. It is quite difficult to relate to a client who does not tell us what he wants. Some sort of a bargaining dialogue has to be established, and the format of this should be determined by us rather than by the client.

7. My final point concerns the emotional issue. In wildlife, there is an emotional issue that is not normally associated with other parameters that would come under ecological land classification. We can start debates, even locally, over a sand pit. Because of this emotional thing, when it comes to wildlife, we try to find a 'culprit'. When 10 000 caribou drowned in Quebec, people were looking for somebody at fault. With the British Columbia wolf situation, the national T.V. network was looking for someone doing something wrong. There is no culprit for forest harvesting -- the forest industry are not really culprits, even though they greatly modify wildlife habitats. This is usually analysed in terms of economic gains or losses.

This emotional issue is important because it can lead, for instance, to the selection of species that you will have to do the habitat classification for. Criteria for selection of species should be based on something other than the emotions.

In conclusion, I would like to pose the question -- "Can wildlife management expect to become an exact science"? I am not sure. I sometimes wonder whether we are not closer to sociology or psychiatry. We are operating at a conceptual level, even though we try to be scientific. We are good with trends, but apart from that, we seem to have some difficulty.

We will never be able to accurately quantify to the extent that is done with tree volume or volumes of surficial materials, such as sand or gravel. I think that as a group we are still generalists and we are looking for a relation to the work of specialists, and that is part of our big problem.

Overall, I think that the workshop was a success. I think that it met the objectives set for it. I think that ensures continuity with the future, which does look good. I think that it is important to remain self critical and try to improve as we progress.

RÉSUMÉ DE L'ATELIER

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Cet atelier avait comme principal objectif de faciliter un échange d'idées. Il avait en outre des objectifs précis dont il a été question dans les exposés du premier jour, dans les discussions de groupe et dans d'autres discussions à caractère non officiel. J'ai essayé, dans un esprit de critique positive, de voir si ces objectifs avaient été atteints. Voici quelques-unes des observations générales que j'ai pu dégager.

Le premier jour, on a discuté de certains progrès technologiques et de méthodes et applications récentes. J'aimerais établir un parallèle entre ces progrès et ce qu'on appelle la courve de "montée dans le train", qui peut être appliquée à toute nouveauté comme la récente technologie des satellites et les nouvelles approches à l'égard des modèles écologiques. Lorsqu'une nouveauté fait son apparition, chacun "monte dans le train" en croyant qu'elle répondra peut-être à toutes les question. Toutefois, on finit par se rendre compte que c'est loin d'être le cas. Les modèles écologiques illustrent bien une telle situation. Les évaluateurs d'incidences envrionmentales nous fournissent des modèles pour prédire quel pourraient être les impacts. Toutefois, ces modèles ont eu tendance à soulever davantage de questions et à faire ressortir des variables problématiques à tel point que nombreux sont ceux qui se sont "découragés" par les modèles écologiques. La même chose s'applique à la technologie des satellites utilisée pour évaluer les habitats fauniques - la technologie accomplit tout le travail à votre place et tout le monde est à même de la comprendre. Cependant, il existe quelques difficultés dont certaines sont d'ordre technique (le couvert, la surface des eaux, les petites régions, etc.). La technologie des satellites représente un excellent outil, qui n'en doit pas moins être utilisé au bon niveau, et il me semble que nous sommes en train de nous en rendre compte. J'ignore à quel point de la courbe nous en sommes arrivés à l'heure actuelle, mais les choses finiront par se stabiliser et la technologie sera utilisée avec le financement appropriée, le personnel correctement formé, l'équipement et les méthodes adéquats, etc. de manière à ce qu'on obtienne des évaluations d'habitat fiables et réalistes.

Ce débat a porté davantage sur les problèmes, humains que sur les problèmes liés à la faune. En fait, dans la gestion des ressources fauniques 90% des problèmes sont probablement des problèmes humains. Compte tenu de cette situation, je propose d'inviter à l'occasion des futurs rencontres ou ateliers au moins un spécialiste des problèmes humains, comme un sociologique ou un psychologue, qui pourrait nous éclairer sur cet aspect de la question.

Pour ce qui a trait aux débats concernant un dépliant possible, tout est encore beaucoup trop imprécis. Nous n'avons pas une vision assez nette de ce que ce dépliant pourrait être. Il nous faut l'aide d'un spécialiste - nous devons lui dire ce que nous voulons pour que le produit obtenu nous représente de manière adéquate.

Les paneaux d'affichage présentés lors de la rencontre était d'une excellent qualité et mettaient en évidence la complexité par rapport à la simplicité de la situation. Par leur approche, leur méthode et le produit final, certains panneaux étaient très simples tandis que d'autres étaient si complexes qu'ils nécessitaient des explications considérables. On a omis d'y aborder certains points : par exemple, il n'y avait rien sur les écotones, il y avait très peu de renseignements sur l'interface terre/eau, et le réparage des "habitats vitaux" est une question qui n'a pas été bien traitée (il s'agit d'une question essentielle dans la planification de l'utilisation des terrs - un habitat vital doit être repéré assez facilement).

J'aimerais maintenant formuler quelques remarques concernant le manuel des lignes directirces pour l'intégration de l'évaluation des ressources fauniques au relevé écologique des terres. En tout, il y a eu à la session plénière quatre exposés. Celui de Tom Hoekstra sur la théorie écologique constitue une base exceleInte pour le manuel. Il donne une solidité à la classification des habitats et crée une certaine forme de hiérachie. Il donne de la validité à la question de la faune.

John Kanas a parlé de plusieurs des problèmes qui l'intéressent comme la successionvégétale. Qu'arrivera-t-il une fois que l'habitat aura fait l'objet d'une classification?

Les changements se produiront-ils rapidement ou seulement à long terme? Si l'habitat se modifie rapidement, il pourrait y avoir des problèmes de classification. Les problèmes de cet ordre doivent être par des spécialistes, comme les membres du Groupe de travail sur la faune.

Les deux autres exposés portaient sur les objectifs, la portée et la méthodologie. Dans l'ensemble, j'ai eu l'impression que toutes les sections de l'ébauche de manuel avaient été bien préparées, compte tenu du fait en particulier qu'il fallait que cette ébauche soit prête pour les débats, au moment de la rencontre.

Quant aux discussions de groupe au sujet du manuel, les membres se sont généralement montrés très actifs et enthousiastes. Malheureusement, certains membres des groupes de discussion n'ont pas pu se préparer aussi bien qu'ils l'auraient souhaité, la copie de l'ébauche leur ayant été remise à peine quelques jours avant la rencontre.

J'aimerais maintenant vous faire part de sept points de vue personnels. Je tente ici d'articuler quelques idées, mais peut-être chacun d'entre vous pourra-t-il le faire à son tour plus tard.

1. Voyons d'abord la complexité par opposition à la simplicité. Cette question est revenue à plusieurs reprises pendant la réunion. Il est difficile de parvenir à concilier l'objectif de "rester simple" avec le fait que l'environnement, et par conséquent toute classification écologique des terres qui le caractérise, est extrêmement complexe. Il y a généralement de nombreuses variables et valeurs associées à n'importe quelle CET. Dans sa présentation de dispositives, Tom Hoekstra a énuméré des paramètres de ressources pendant pratiquement soixante minutes sans arrête. Il existe de nombreuses variables, mais certaines pourraient peut-être être exclues (c'est-à-dire qu'il faudrait choisir les variables avec plus de circonspection). Nous devrions également surveiller davantage les cas où il y a des relations de cause à effet.

2. En deuxième lieu, j'aimerais parler des écotones - toutes les espèces d'écotones, y compris l'interface terre/eau et toutes les sortes d'habitats mixtes. Sur le plan de l'utilisation des terres, l'écotone représente une zone terrestre très importante. On déclare dans le manuel que les analystes biopysiques ont tendance à éviter les écotones, et le paneaux d'affichage ne semblent pas en avoir fait mention. Les écotones représentent une question du plus haut intérêt pour nous parce qu'ils peuvent s'avérer d'une importance capitale en tant qu'habitats de premier plan. Si nous essayons toujours de nous écarter de ce sujet, il ne sera jamais possible de nous faire une idée réelle de ce que nous voulons accomplir pour l'avenir de la faune. Le groupe doit un jour ou l'autre s'attaquer à la question des écotones, faute de quoi il sera définitivement exposé aux critiques extérieures sur ce point.

3. En général, l'intervention du secteur halieutique au sein du groupe de travail est limitée. Les responsables des pêches contactés expriment leur intérêt à l'égard du groupe. A tout le moins, nous devrions être en mesure de nous occuper de la zone riveraine. Nous avons eu la chance d'avoir à l'atelier des affiches sur les habitats lotiques, ce qui représente un pas dans la bonne direction. Mises à part les frayères en tant que habitat vital pour le poisson, on ne semble guère se préoccuper de l'environnement aquatique comparativement aux habitats terrestres. Voilà une lacune précise qu'il importe de combler d'une manière ou d'une autre. On pourrait peut-être organiser un atelier spécialement pour aborder la question des pêches ou le milieu aquatique, ou même les deux.

4. La dimension des habitats peut également être soulevée, ce qui nous amène à la question de la diversité, comme l'a si bien montré Tom Hoekstra dans son exposé. Il est certain que la diversité comporte des avantages, mais il ne faut pas non plus oublier que certaines espèces ont besoin de grandes bandes de territoire assez homogène. Par conséquent, il importe de ne pas perdre de vue les dimensions que ces bandes doivent avoir.

5. Mon cinquième point porte sur la conservation des habitats. Comme je travaille avec des petites aires isolées dans la région montréalaise, les planificateurs me demanden souvent quels sont celles qu'il faut conserver. Quelques biologistes marins répondront qu'il faut toutes les garder. Mais la situation se complique lorsqu'on tient compte en même temps des concepts grandioses des aires d'aménagement. Les planificateurs posent également des questions du genre de celle-ci : "Si nous ne pouvons toucher à cette zone jusqu'où pouvons-nous l'approcher?" C'est une question à laquelle je ne saurais répondre.

6. Il ya eu beaucoup de discussions au sujet de la commercialisation et de la contribution

des clients (p. ex. les planificateurs de l'utilisation des terres). Dans un contrat normal, c'est le client qui rédige les conditions; c'est pourquoi je pense que les responsables de l'aménagement des terres ou d'autres clients auraient dû être présents à l'atelier. Il est très difficile d'établir un rapport avec un client qui ne nous informe pas de ses besoins. Il convient d'établir un dialogue pour négocier, dont la forme doit être déterminée par nous plutôt que par le client.

7. Pour finir, je veux parler du problème émotif. La question de la faune comporte un aspect émotif qui normalement n'est pas associé à d'autres paramètres inhérents à la classification écologique des terres. Nous pouvons entamer des débats, même à l'échelon local, au sujet d'une sablière. Mais quand il s'agit de la faune, nous essayons de trouver un "coupable" à cause de ce facteur émotionnel. Lorsque 10 000 caribous ont péri noyée au Québec, le public cherchait un coupable. A propos de la situation des loups en Colombie-Britannique le réseau de télévision national cherchait qui avait commis une erreur. Avec l'exploitation forestière il n'y a pas de coupable, cette industrie n'est pas vraiment fautive même si elle modifie considérablement les habitat fauniques. C'est généralement en termes de gains ou de pertes économiques que cette dernière situation en termes de gains ou de pertes économiques que cette dernière situation est analysée.

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